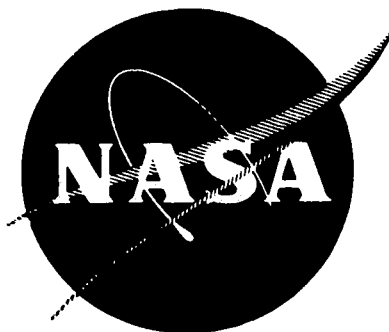


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NASA CR-120980  
BAC Report No. 8654-953003



# FINAL REPORT APPENDIX

## NONDESTRUCTIVE TESTS OF REGENERATIVE CHAMBERS

By

G. A. MALONE  
R. STAUFFIS  
R. WOOD

Prepared For  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
JULY 1972

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**FINAL REPORT - APPENDIX**  
**NONDESTRUCTIVE TESTS OF REGENERATIVE CHAMBERS**

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Prepared for  
National Aeronautics and Space Administration

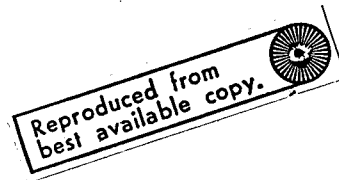
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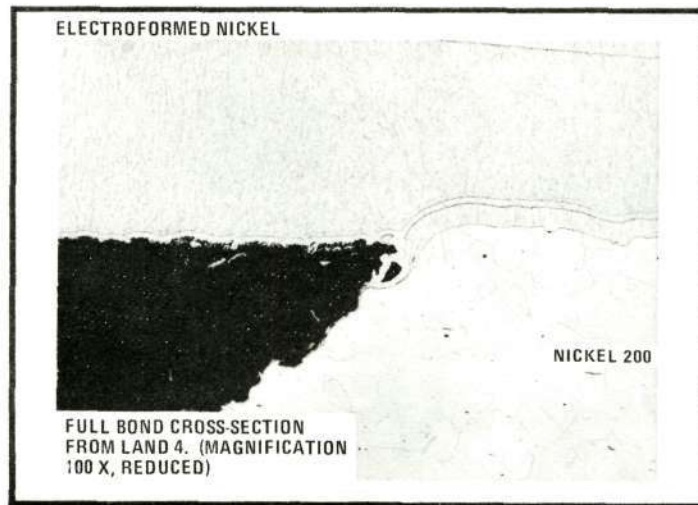
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# CONTENTS

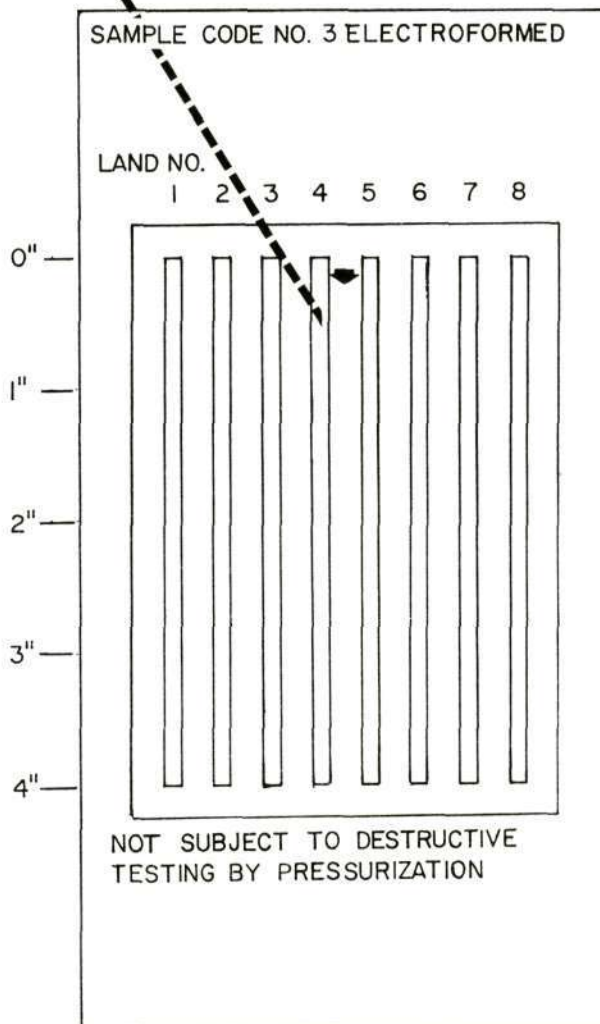
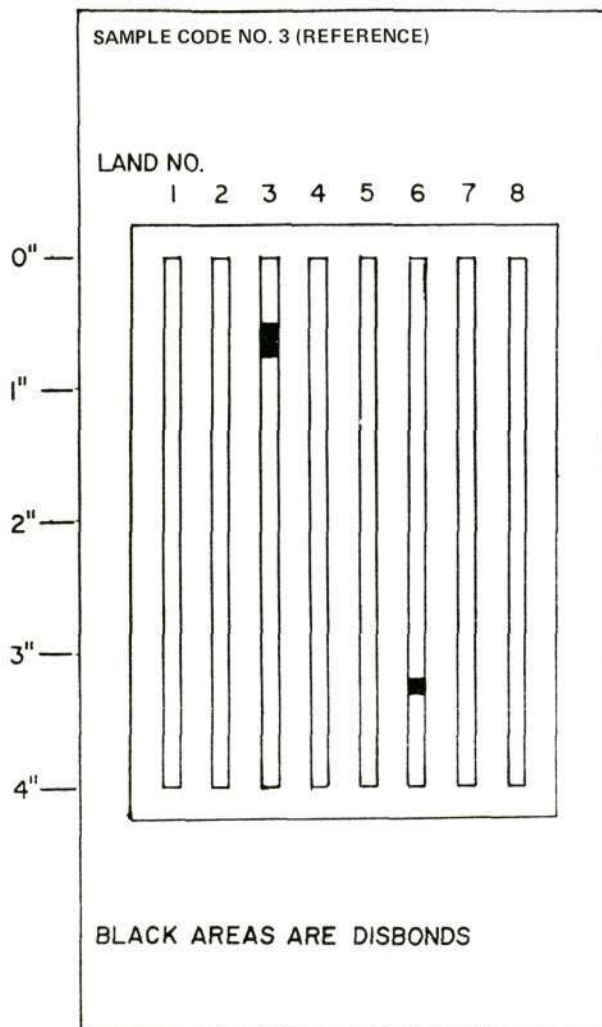
Figure	Test Panel No.	Planned Bond Type	Page
A-1	3*	Electroformed Full With Defect	2
A-2	6	Electroformed Full With Defect	4
A-3	1	Electroformed Full Without Defect	6
A-4	10	Electroformed Full Without Defect	8
A-5	11	Electroformed Full Without Defect	10
A-6	2*	Electroformed Weak Pattern 1	12
A-7	13	Electroformed Weak Pattern 1	14
A-8	5	Electroformed Weak Pattern 2	16
A-9	8	Electroformed Weak Pattern 2	18
A-10	9	Electroformed Weak Pattern 3	20
A-11	7*	Electroformed Nonbond Pattern 1	22
A-12	12	Electroformed Nonbond Pattern 1	24
A-13	4	Electroformed Nonbond Pattern 2	26
A-14	15	Electroformed Nonbond Pattern 2	28
A-15	14	Electroformed Nonbond Pattern 3	30
A-16	31*	Brazed Full With Defect	32
A-17	20	Brazed Full Without Defect	34
A-18	21	Brazed Full Without Defect	36
A-19	35	Brazed Full Without Defect	38
A-20	45	Brazed Full Without Defect	40
A-21	22*	Brazed Weak Pattern 1	42
A-22	24	Brazed Weak Pattern 1	44
A-23	23	Brazed Weak Pattern 2	46
A-24	28	Brazed Weak Pattern 2	48
A-25	18	Brazed Weak Pattern 3	50
A-26	17	Brazed Nonbond	52
A-27	26*	Brazed Nonbond	54
A-28	30	Brazed Nonbond	56
A-29	33	Brazed Nonbond	58
A-30	38	Brazed Nonbond	60
A-31	40*	Diffusion Full With Defect	62
A-32	19	Diffusion Full Without Defect	64
A-33	27	Diffusion Full Without Defect	66
A-34	32	Diffusion Full Without Defect	68
A-35	37	Diffusion Full Without Defect	70
A-36	36	Diffusion Weak Pattern 1	72
A-37	48*	Diffusion Weak Pattern 1	74
A-38	34	Diffusion Weak Pattern 2	76
A-39	29	Diffusion Weak Pattern 3	78
A-40	43	Diffusion Weak Pattern 3	80
A-41	39*	Diffusion Nonbond	82
A-42	41	Diffusion Nonbond	84
A-43	42	Diffusion Nonbond	86
A-44	44	Diffusion Nonbond	88
A-45	49	Diffusion Nonbond	90

\* Reference Panels not Destructively Evaluated





ELECTROFORMED FULL BONDS WITH DEFECTS



TEST RESULTS ON ELECTROFORMED FULL BOND PANEL NO. 3

FIGURE A-1

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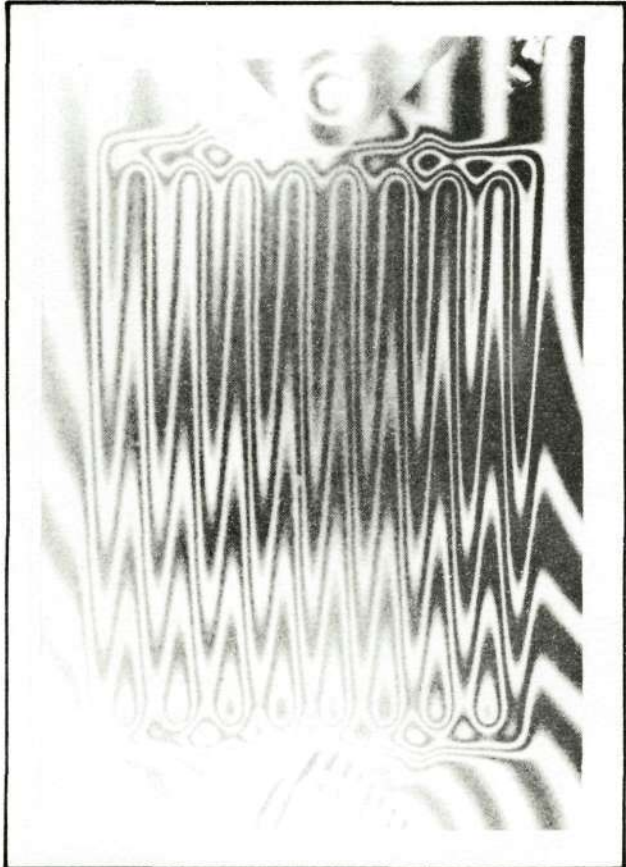


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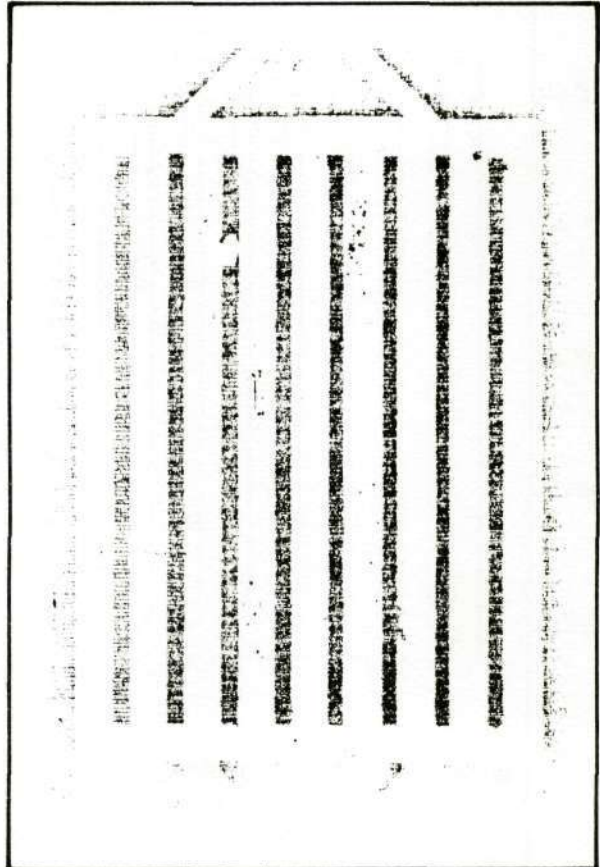
3

Non-Standard Recording No Data Presented

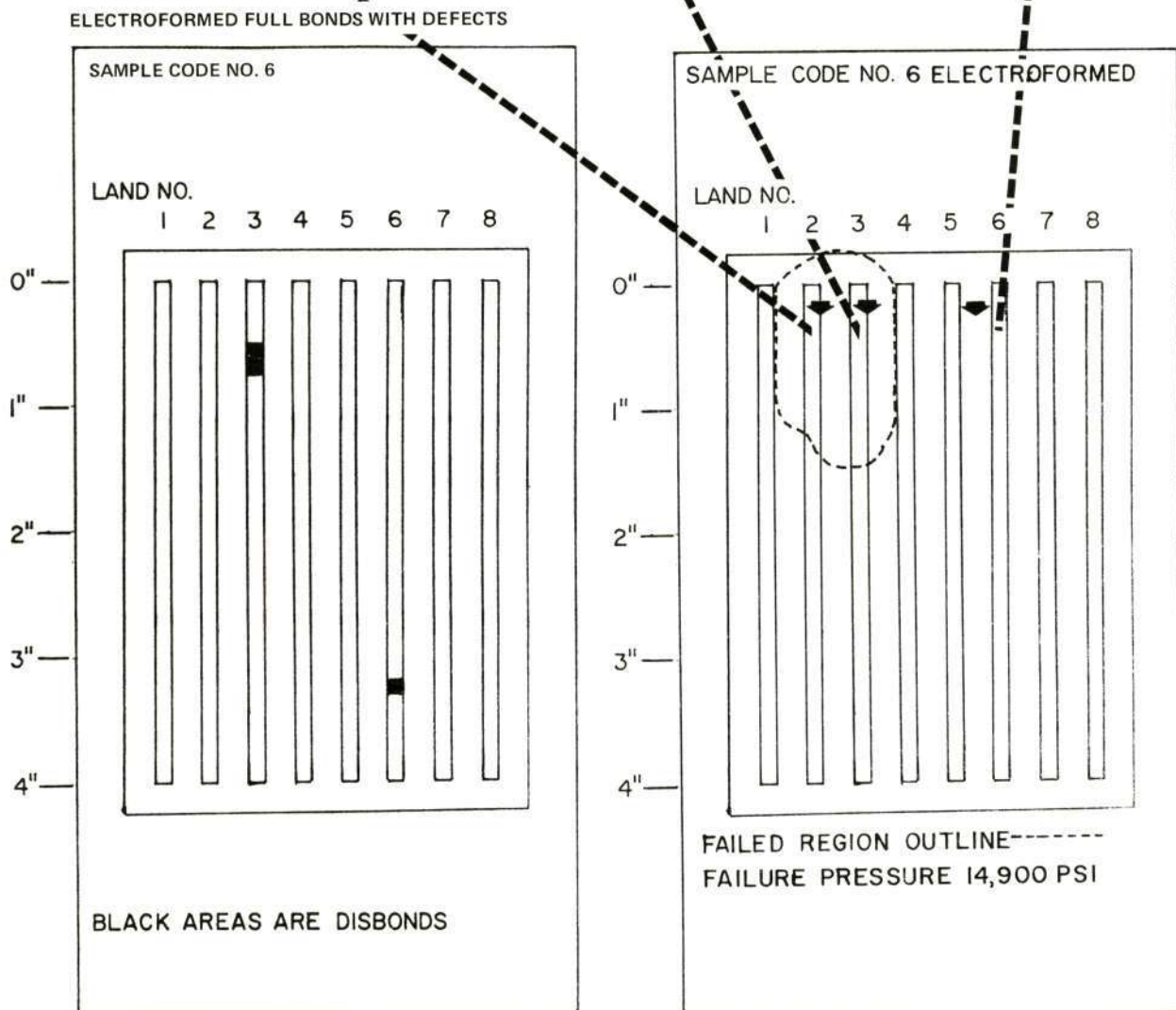
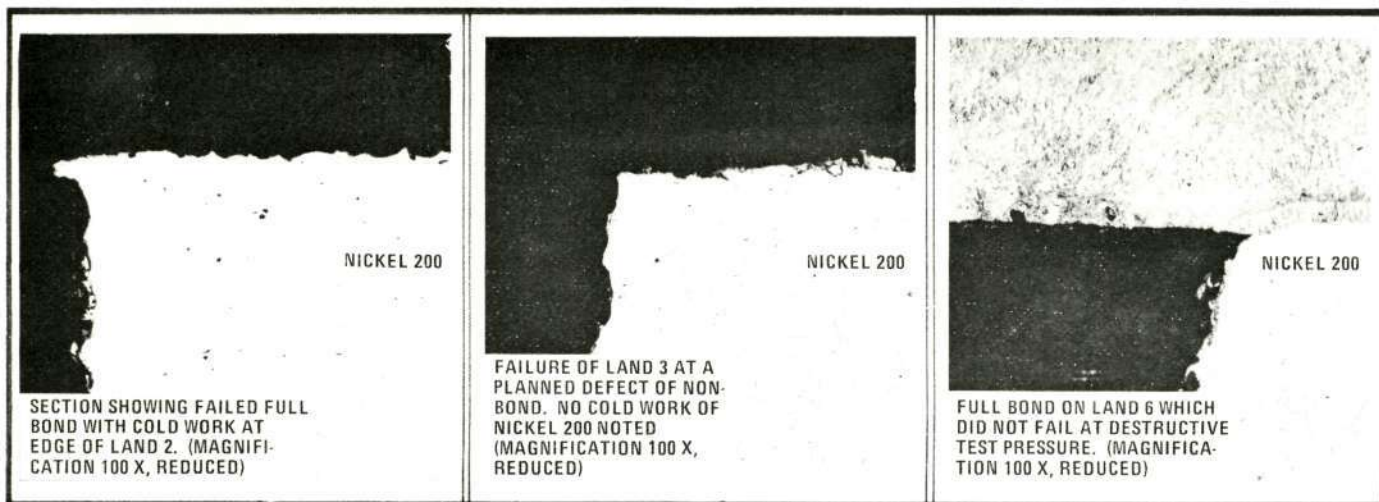
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TEST PRESSURE - 500 PSI



TEST RESULTS FOR ELECTROFORMED FULL BOND PANEL NO. 6

FIGURE A-2

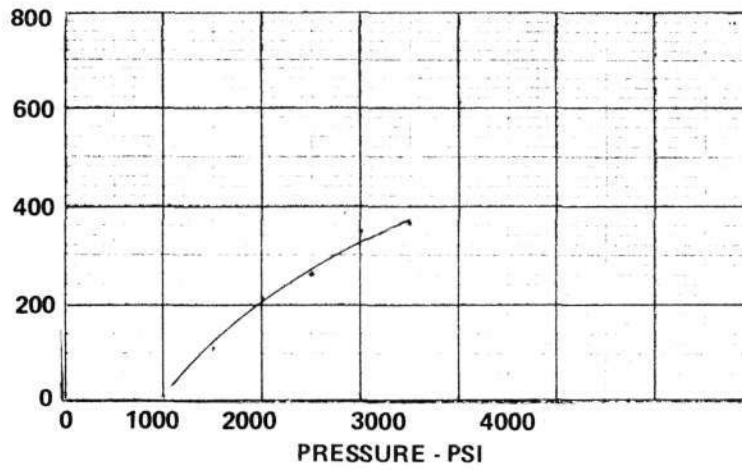


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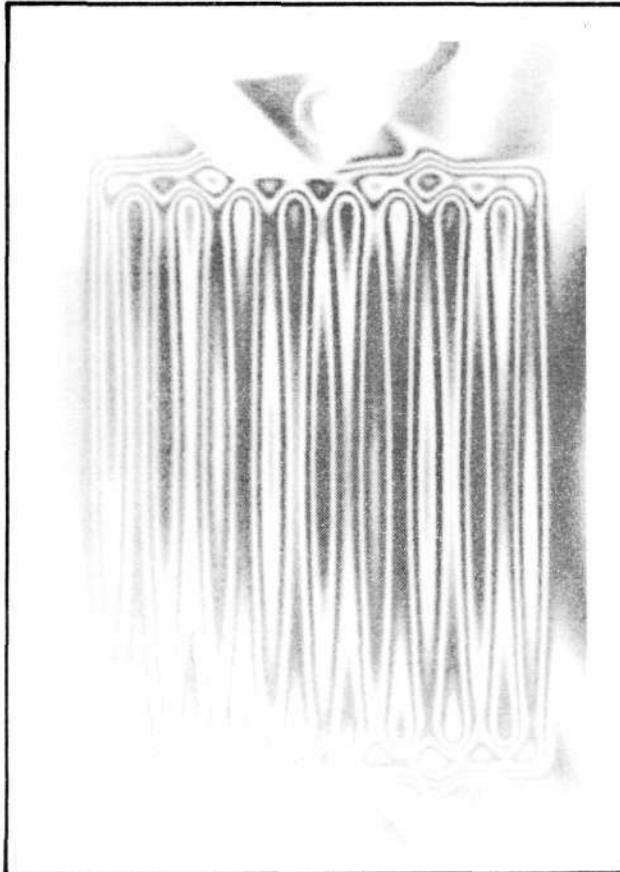
6

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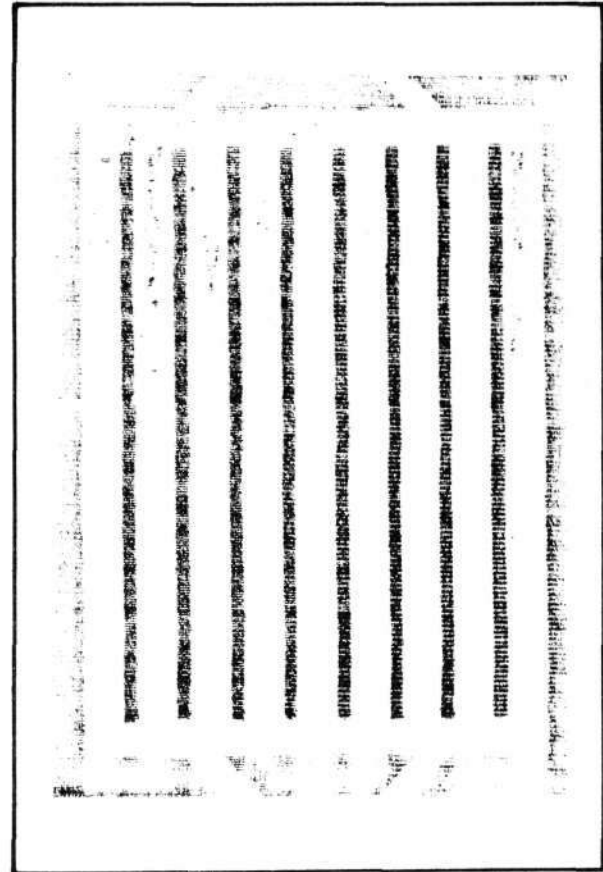


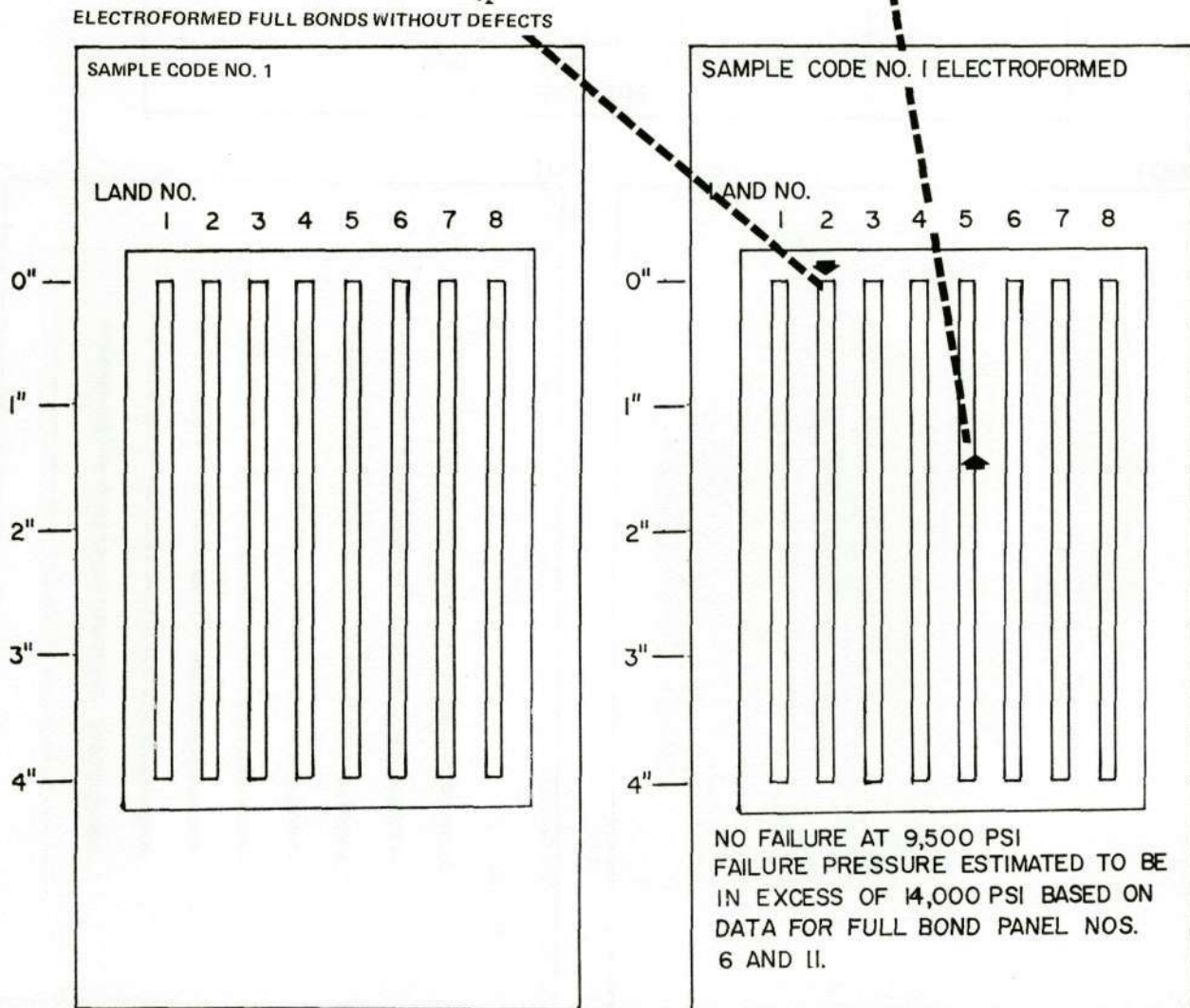
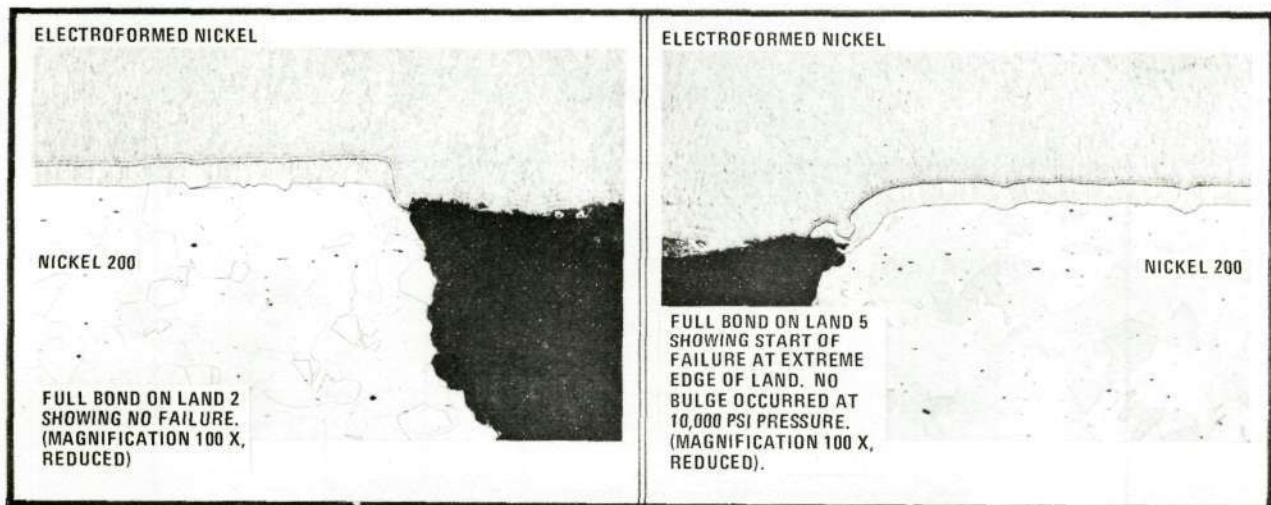
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TEST PRESSURE - 500 PSI

UT

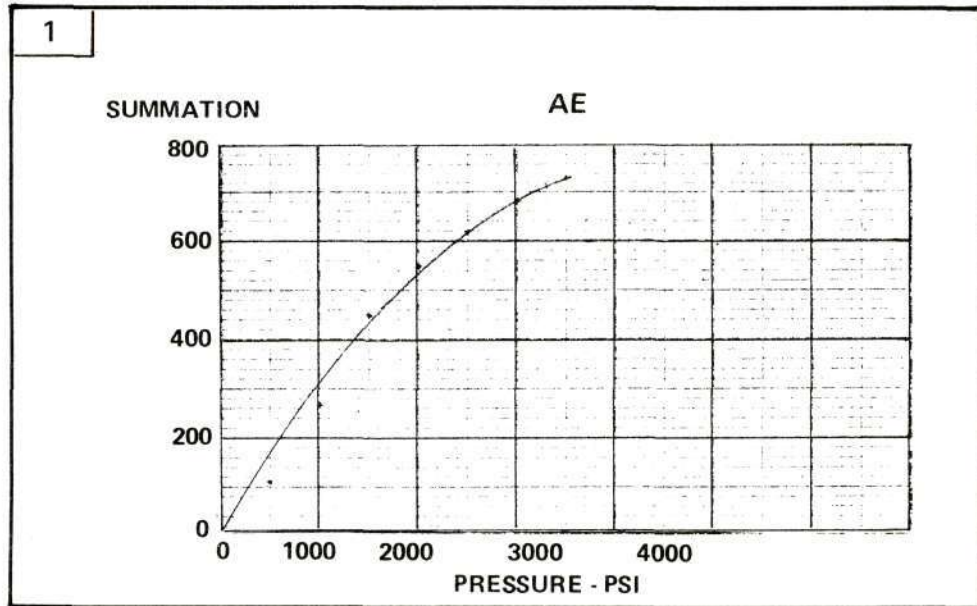




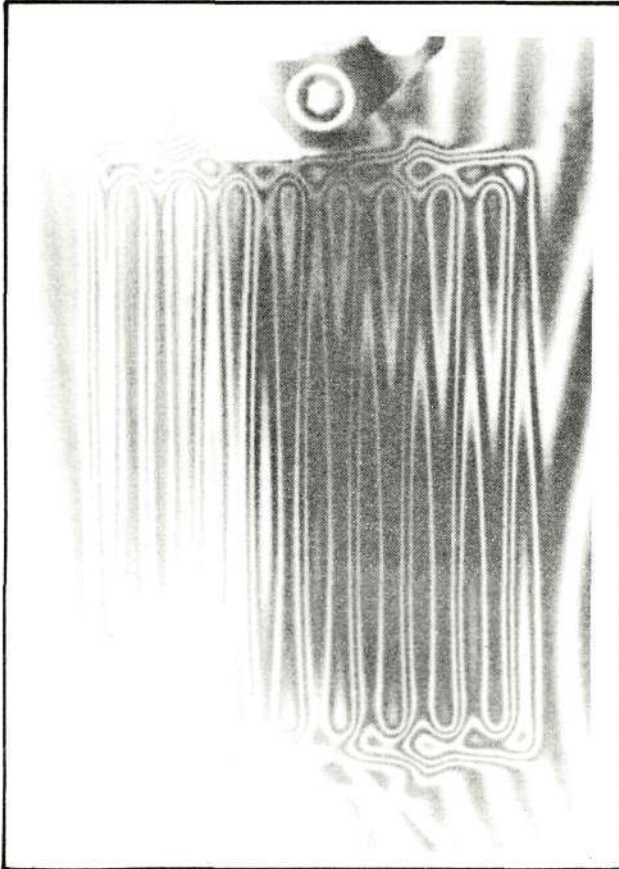
TEST RESULTS ON ELECTROFORMED FULL BOND PANEL NO. 1

FIGURE A-3

## ELECTROFORM NDE RESULTS

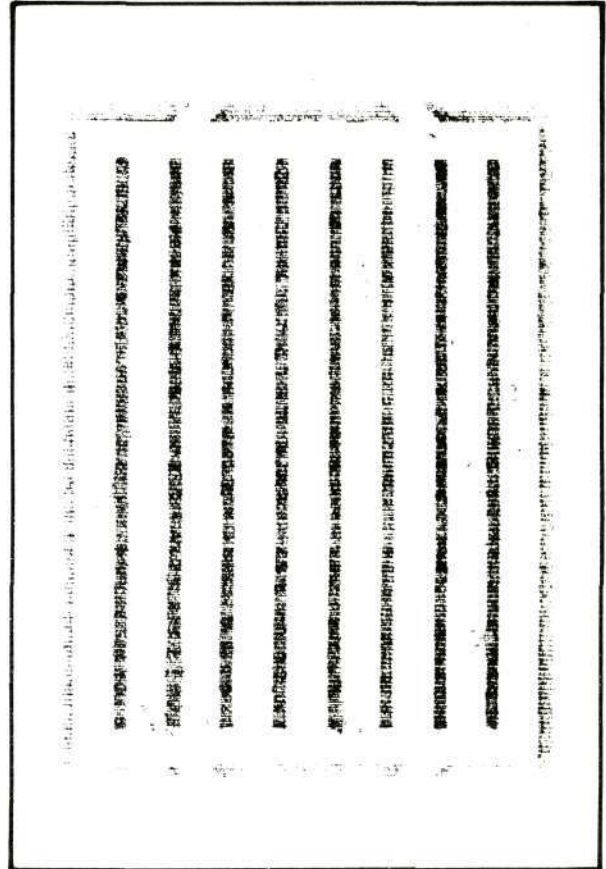


HNDT

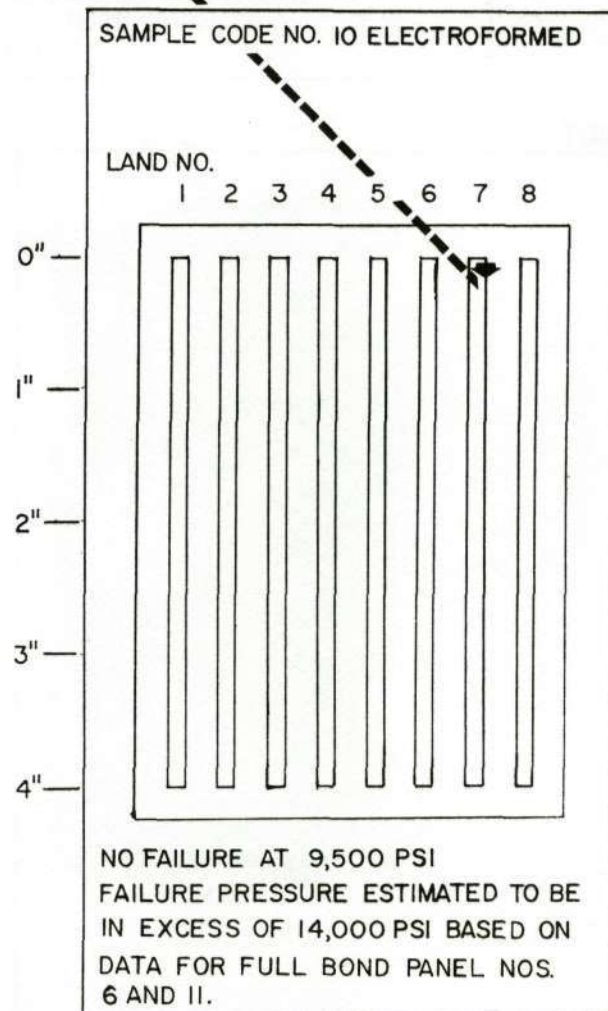
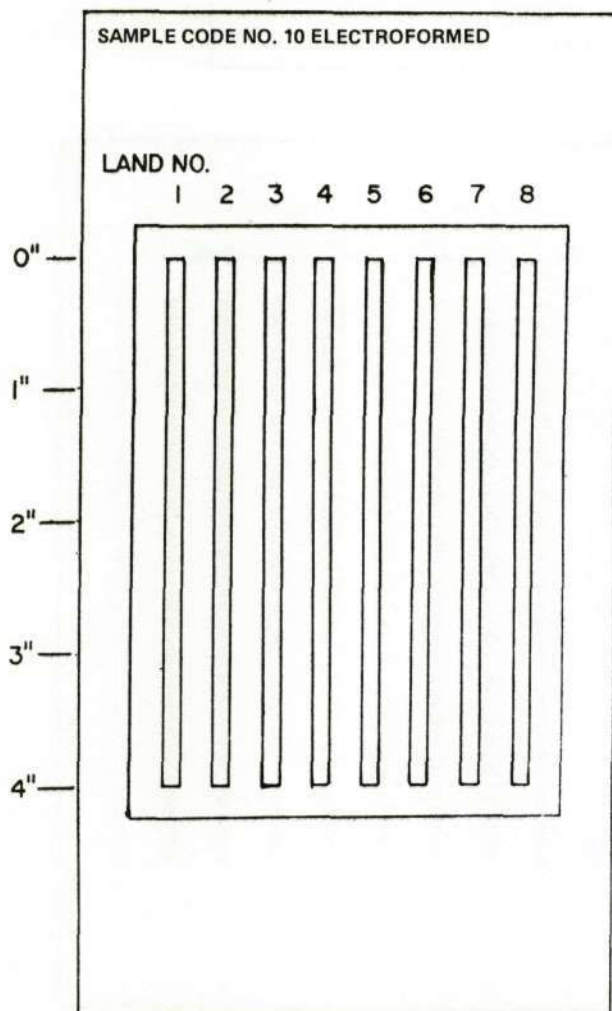
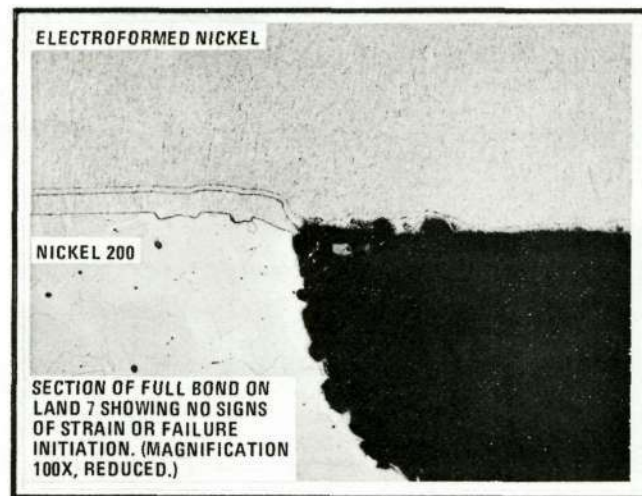


TEST PRESSURE - 500 PSI

UT



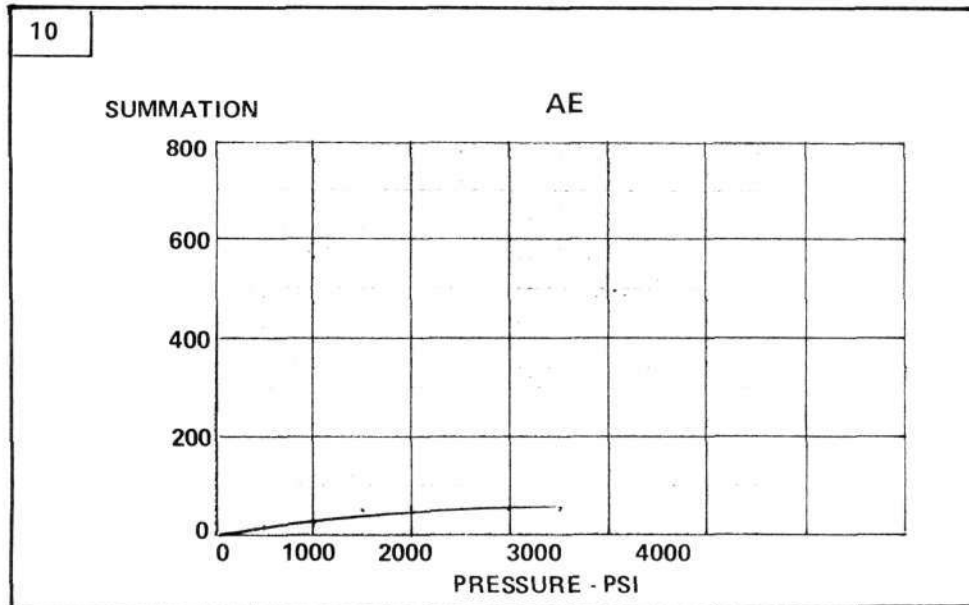




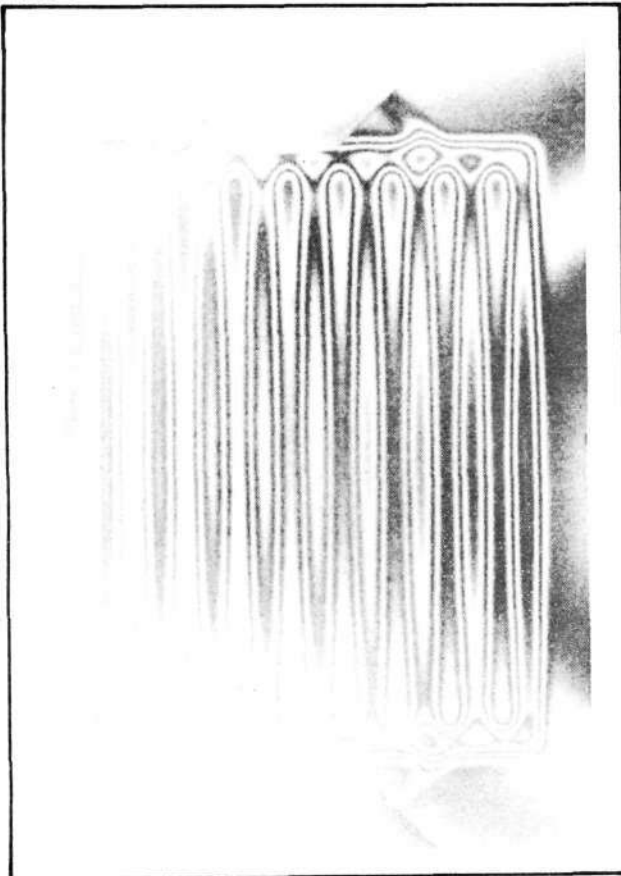
TEST RESULTS ON ELECTROFORMED FULL BOND PANEL NO. 10

FIGURE A-4

# ELECTROFORM CONT'D

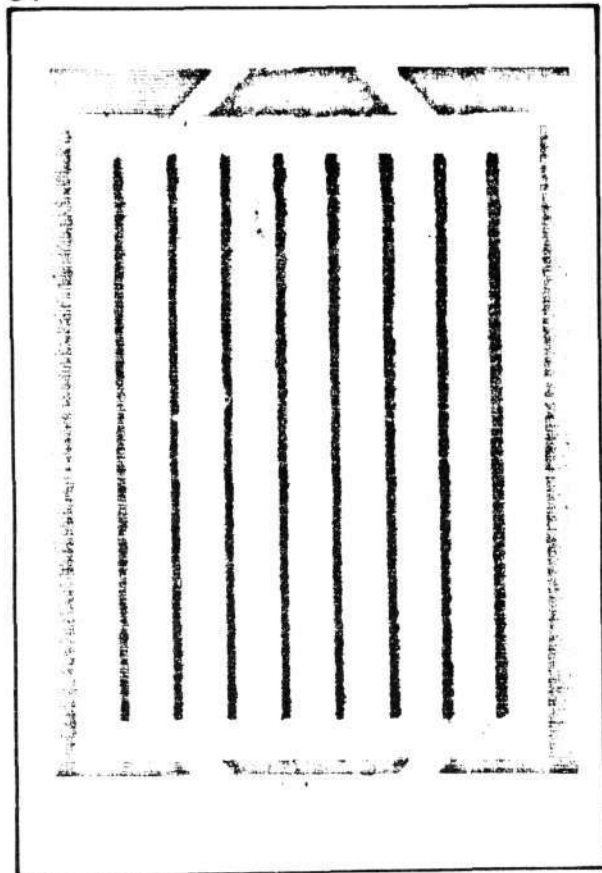


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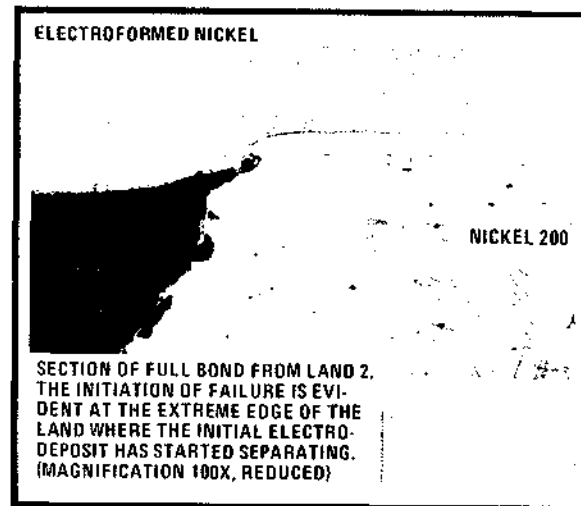


TEST PRESSURE - 500 PSI

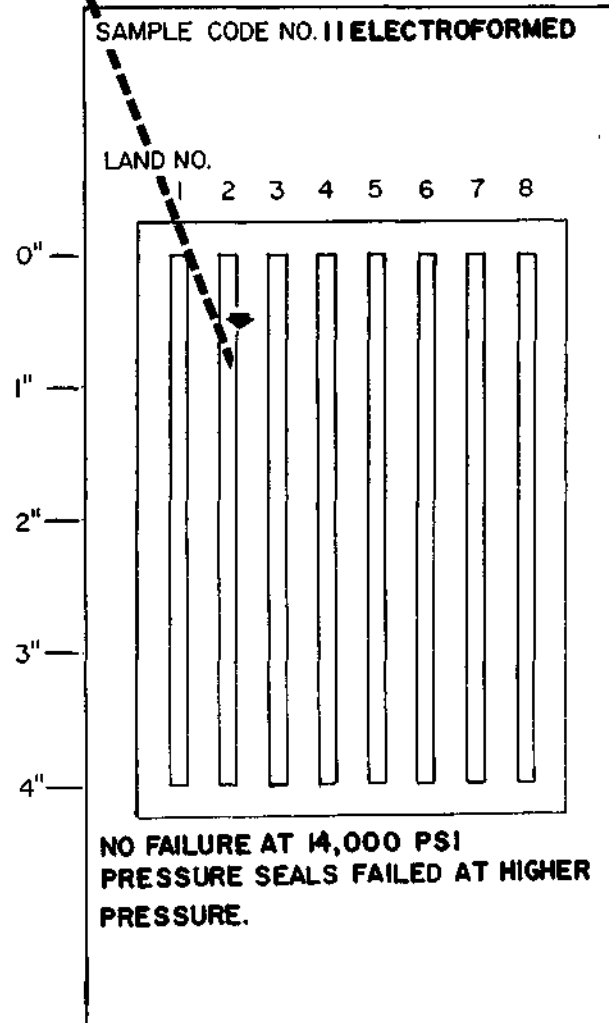
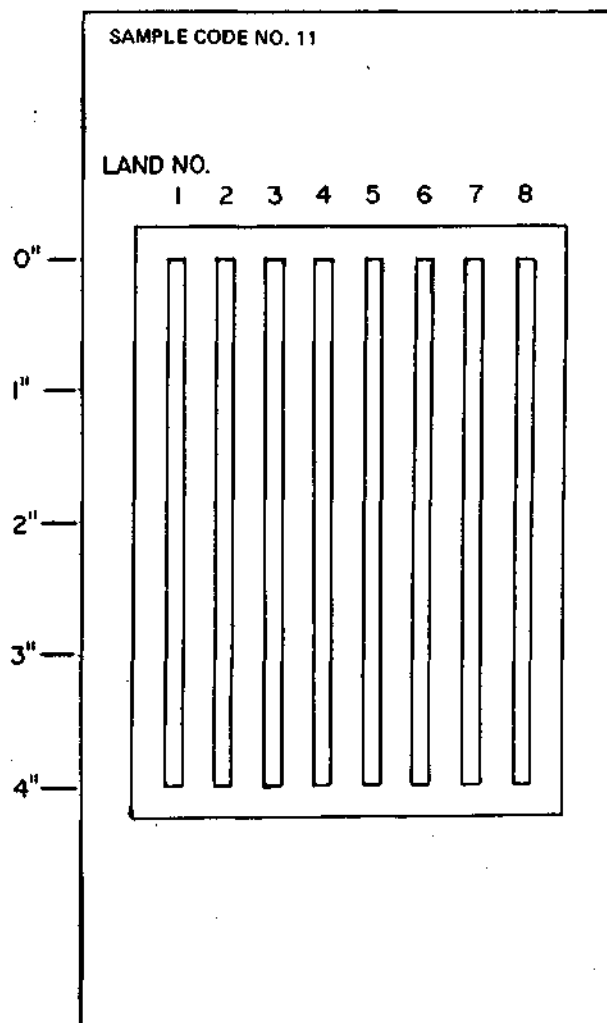
UT







**ELECTROFORMED FULL BONDS WITHOUT DEFECTS**



**TEST RESULTS ON ELECTROFORMED FULL BOND PANEL NO. 11**

**FIGURE A-5.**

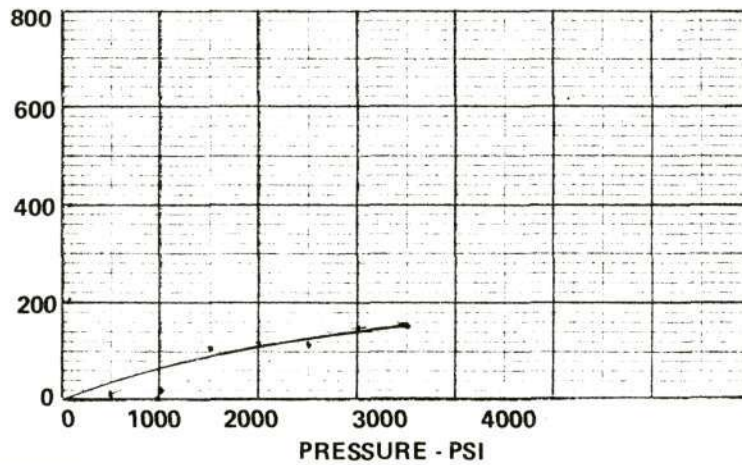
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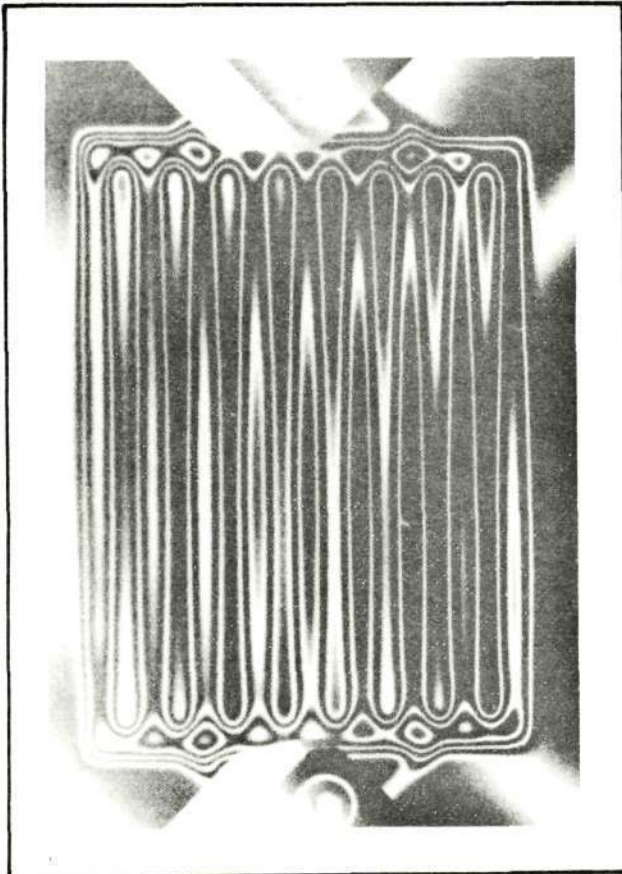
11

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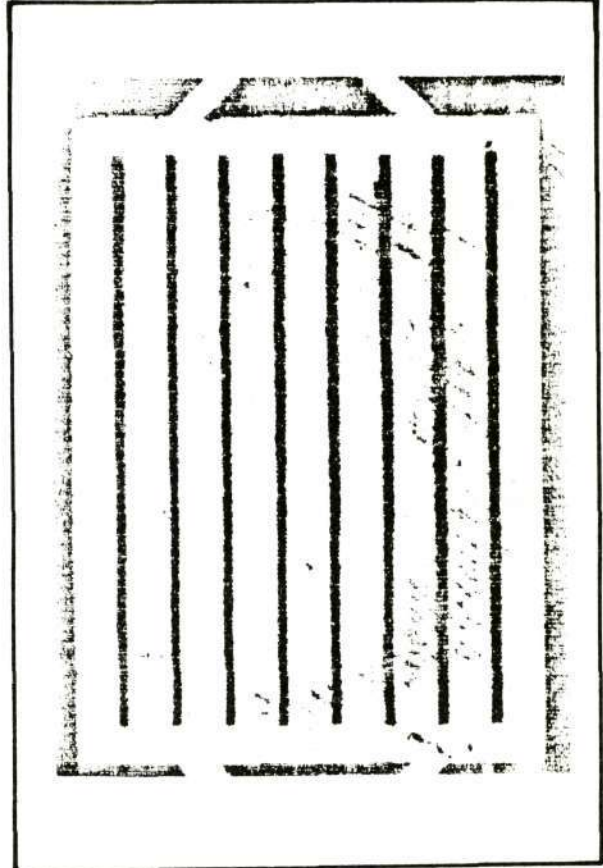


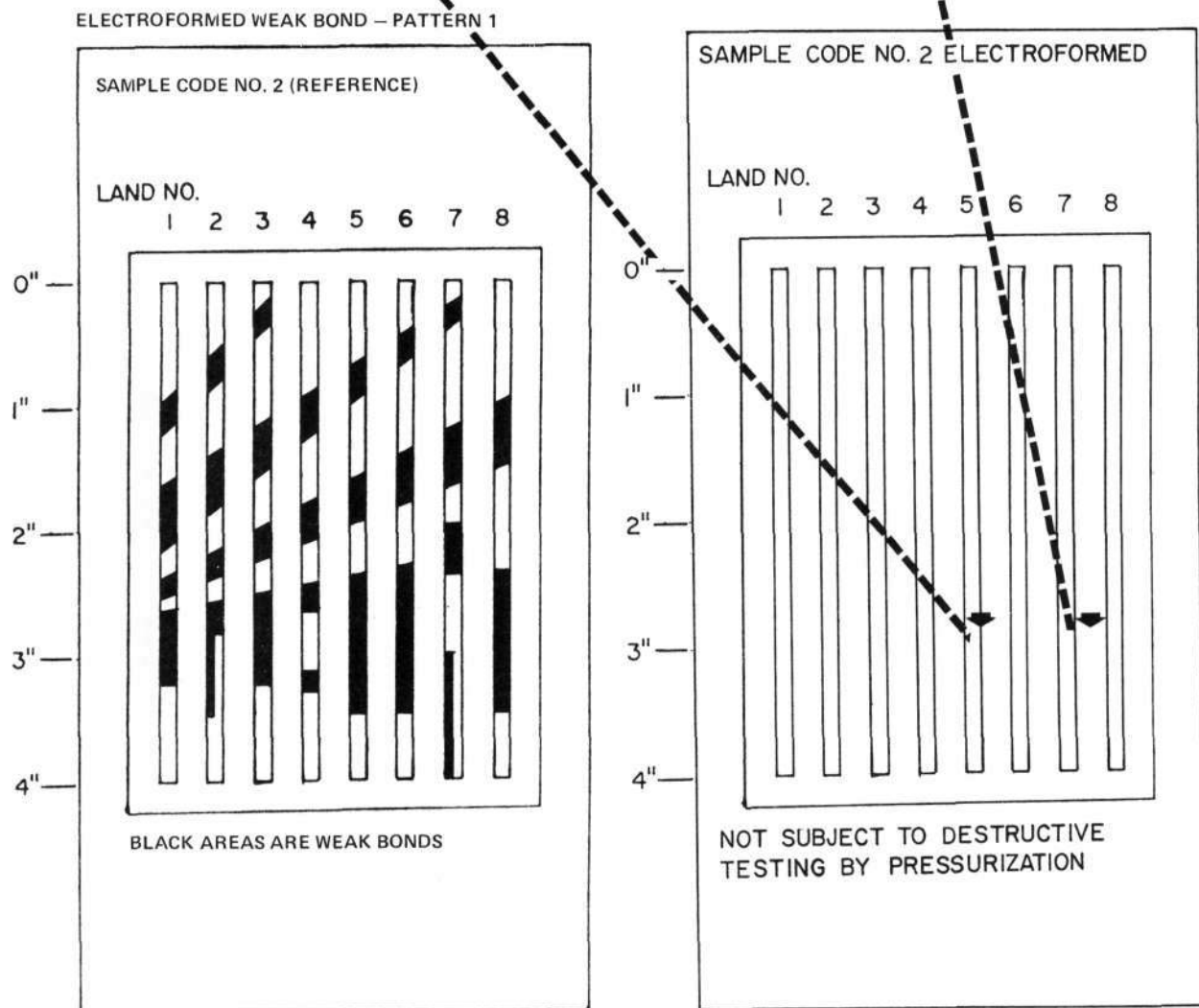
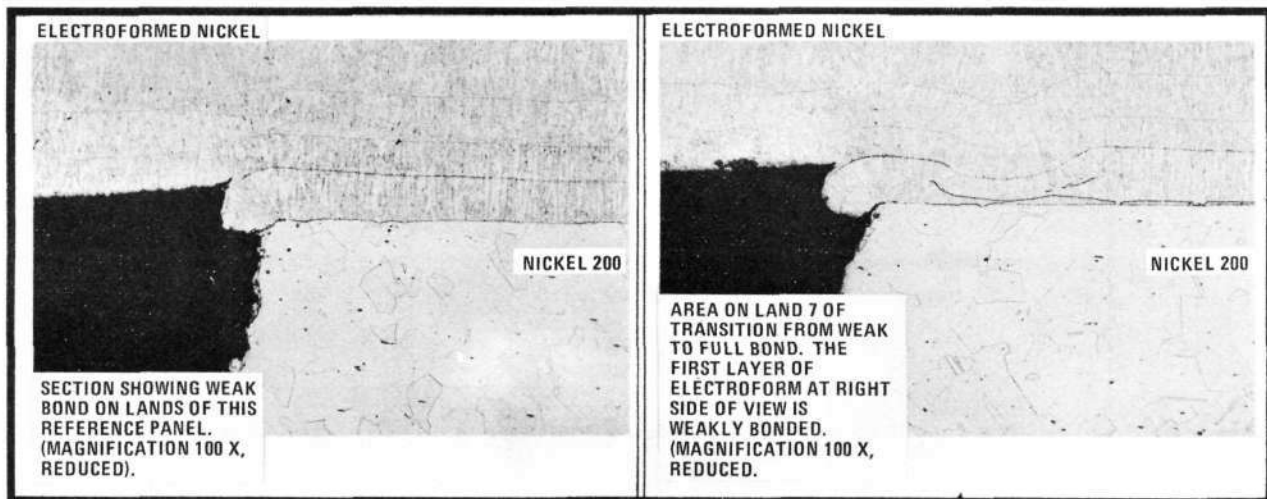
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TEST PRESSURE - 500 PSI

UT

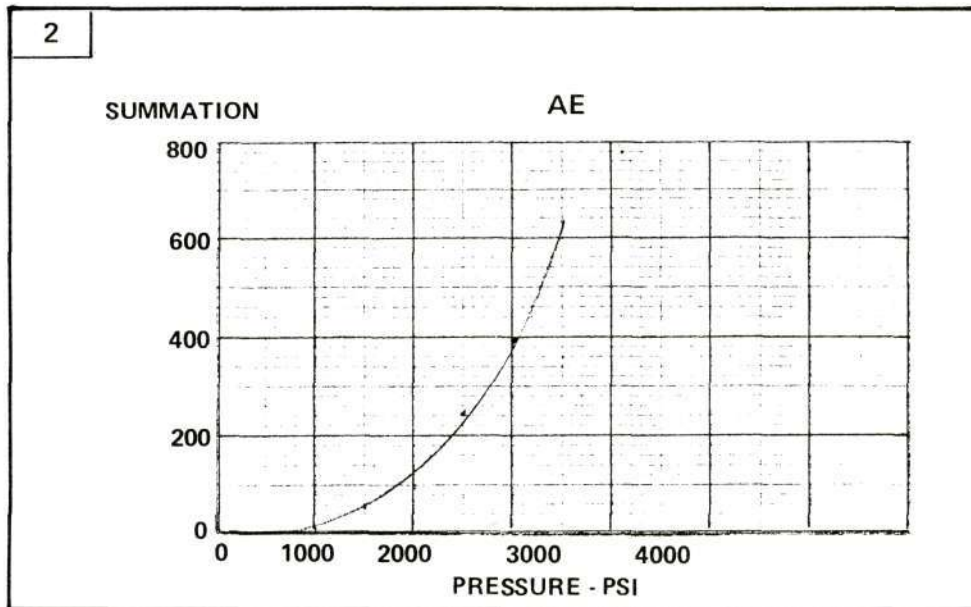




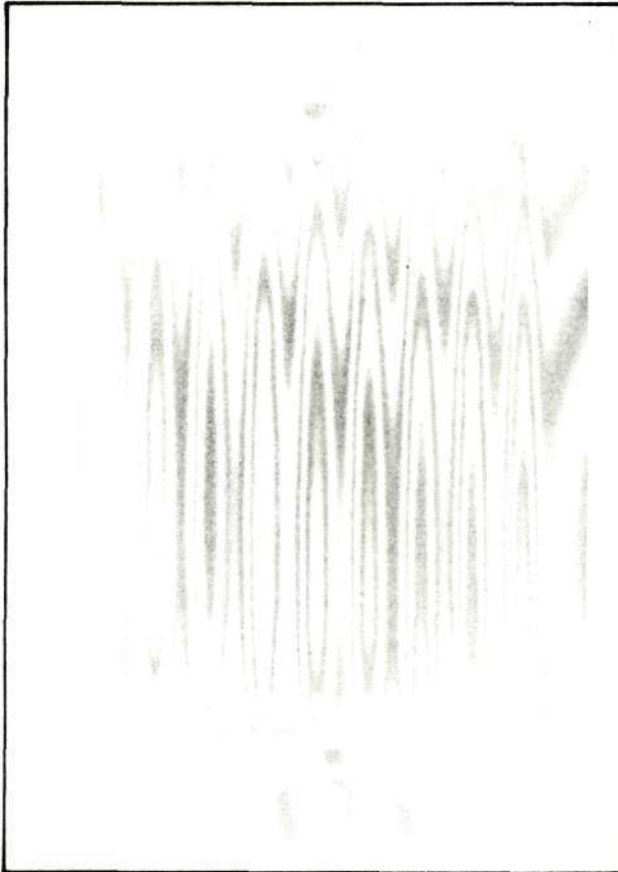
TEST RESULTS ON ELECTROFORMED WEAK BOND PANEL NO. 2

FIGURE A-6

## ELECTROFORM CONT'D

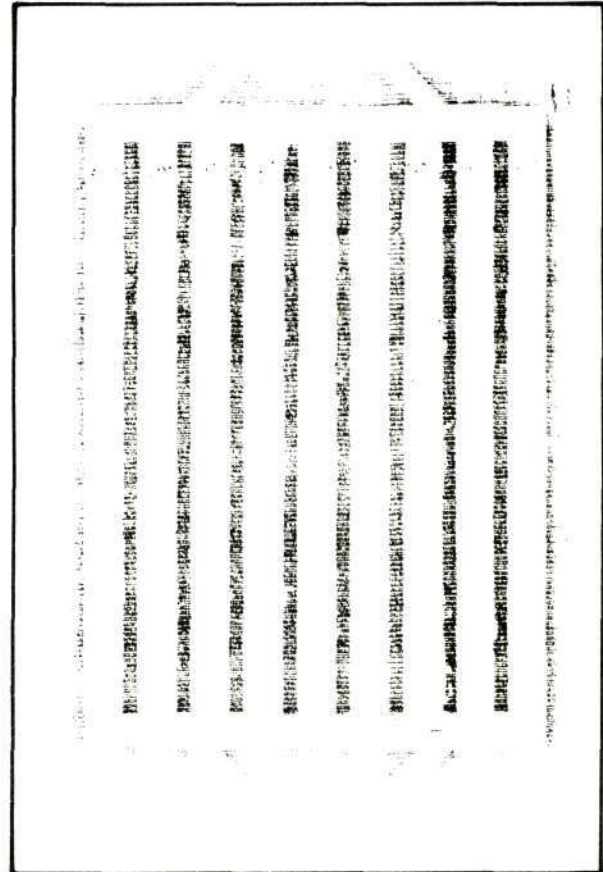


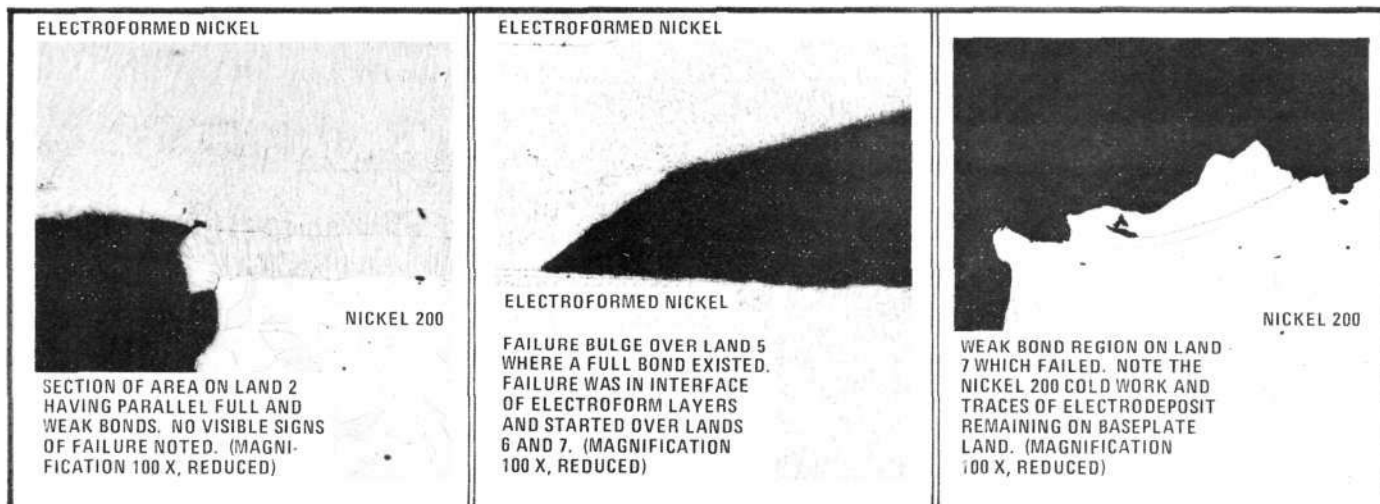
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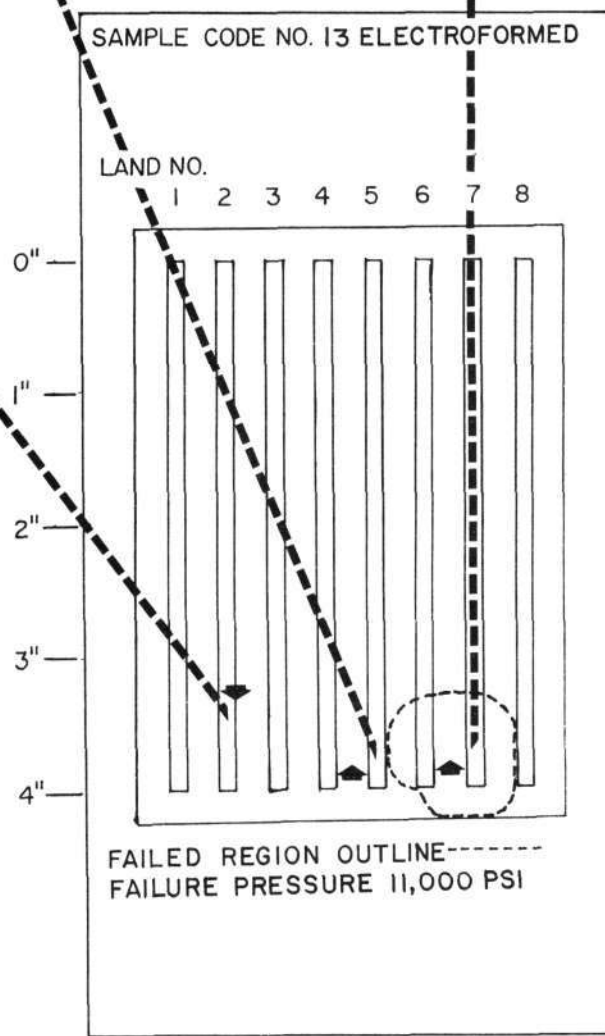
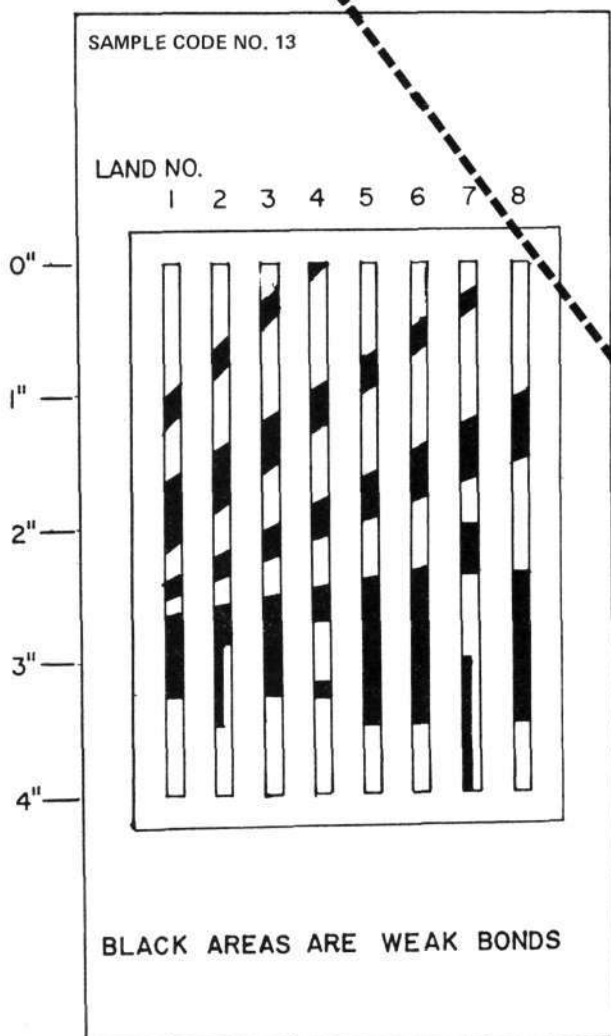
TEST PRESSURE - 500 PSI

UT





**ELECTROFORMED WEAK BOND PATTERN 1**



TEST RESULTS ON ELECTROFORMED WEAK BOND PANEL NO. 13

FIGURE A-7

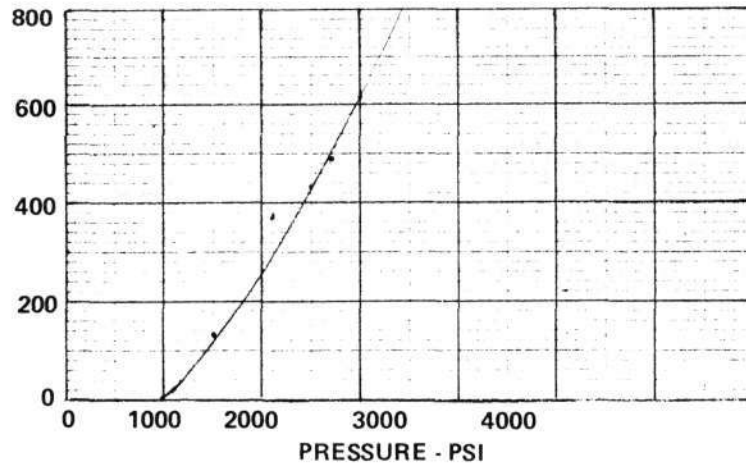


# ELECTROFORM CONT'D

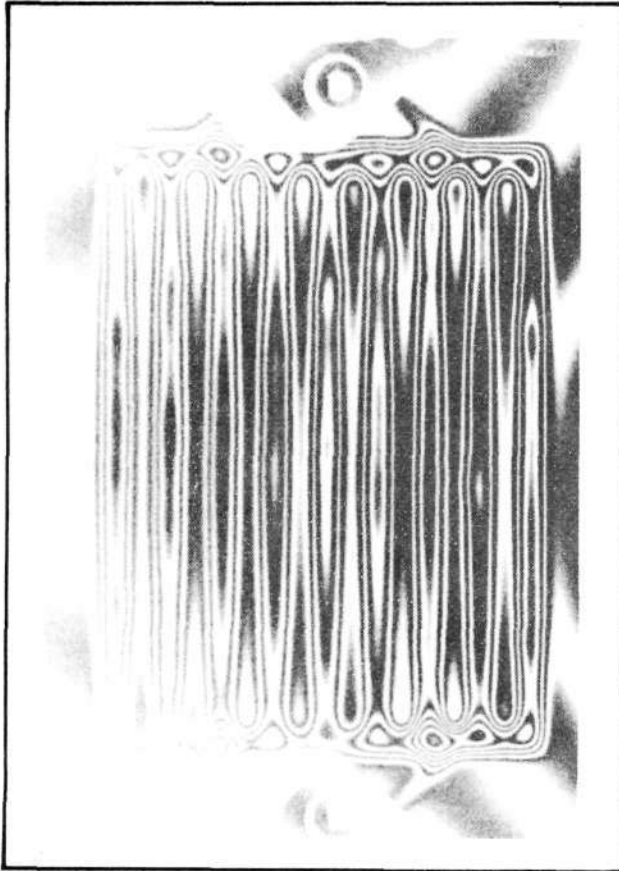
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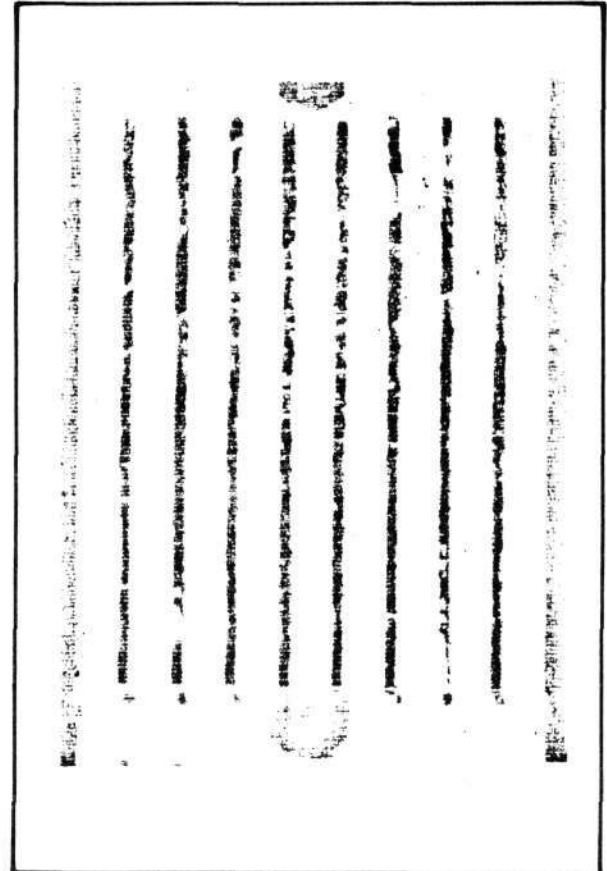


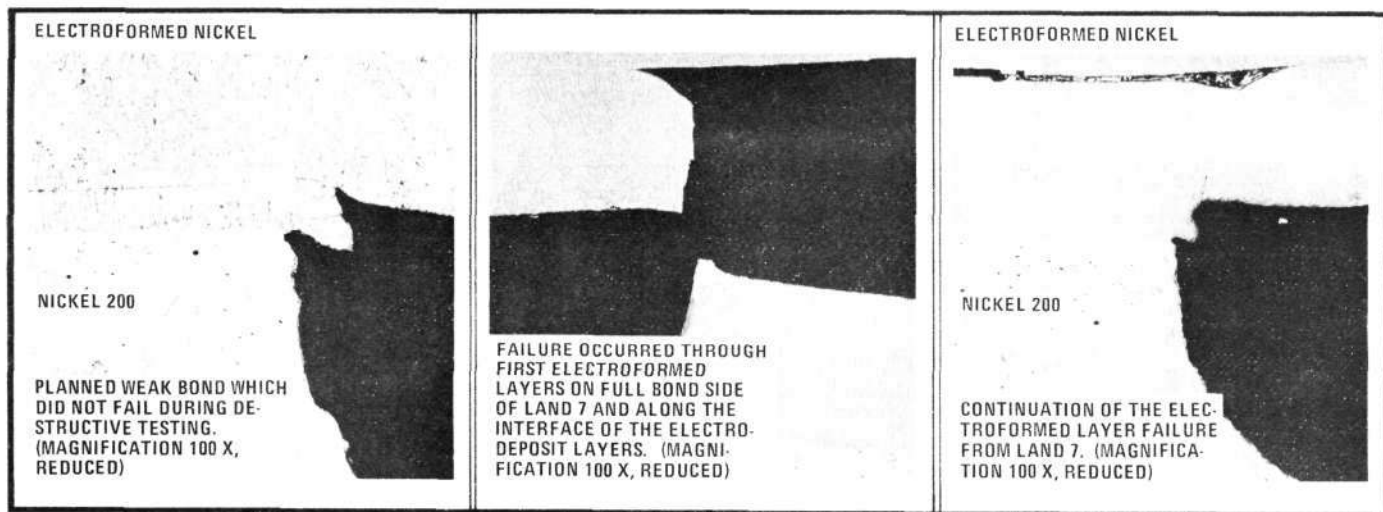
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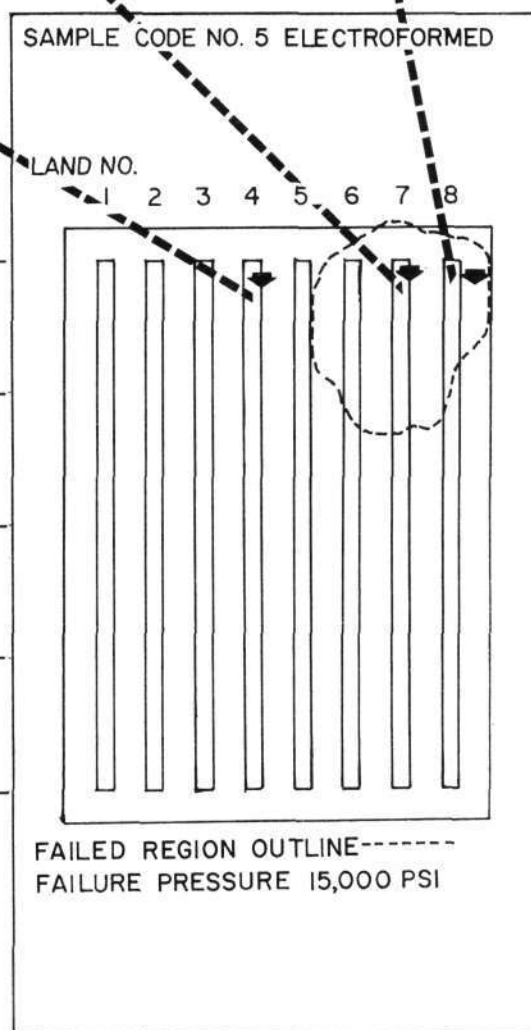
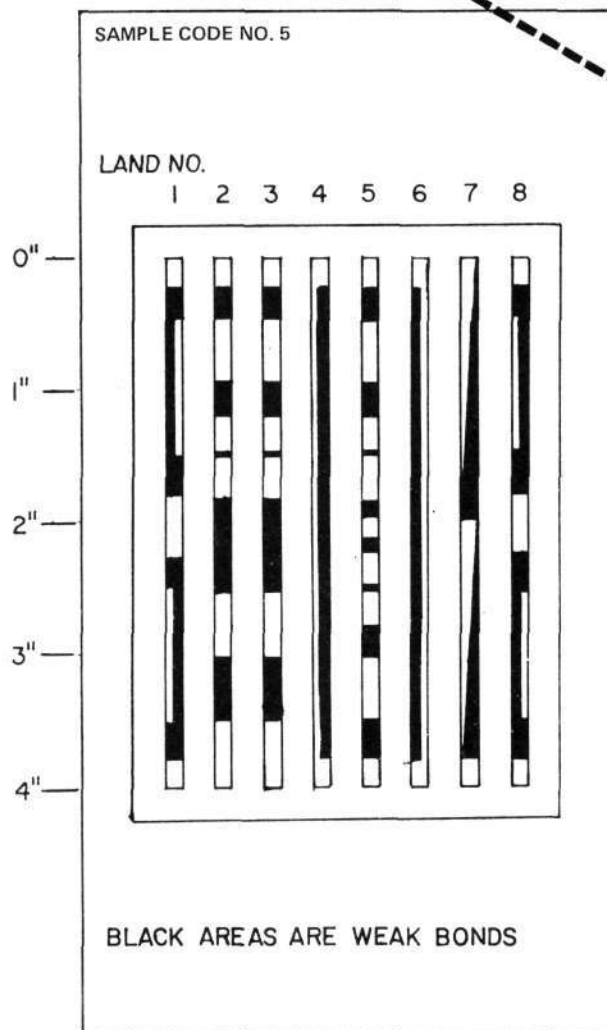
TEST PRESSURE - 500 PSI

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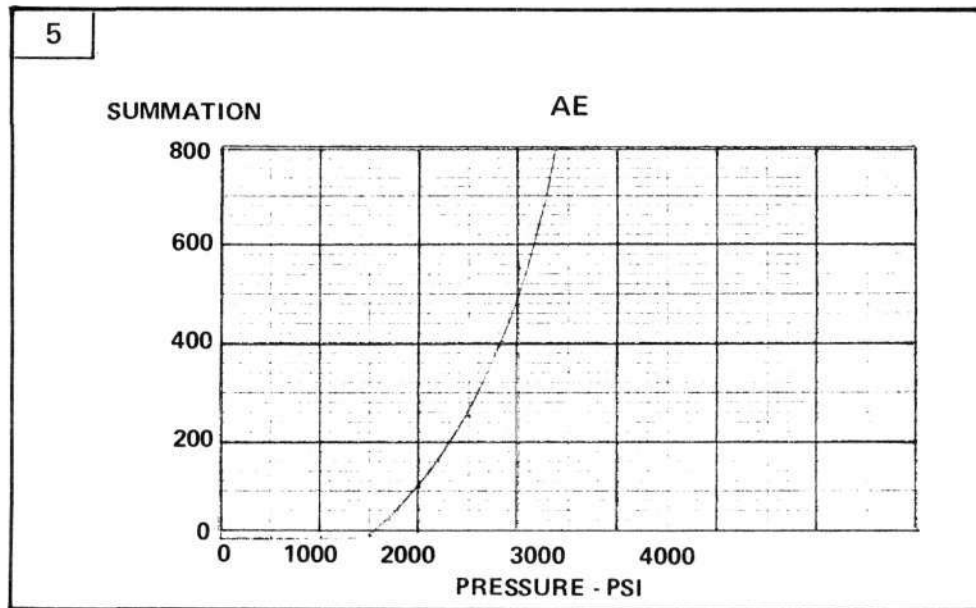
# ELECTROFORMED WEAK BONDS - PATTERN 2



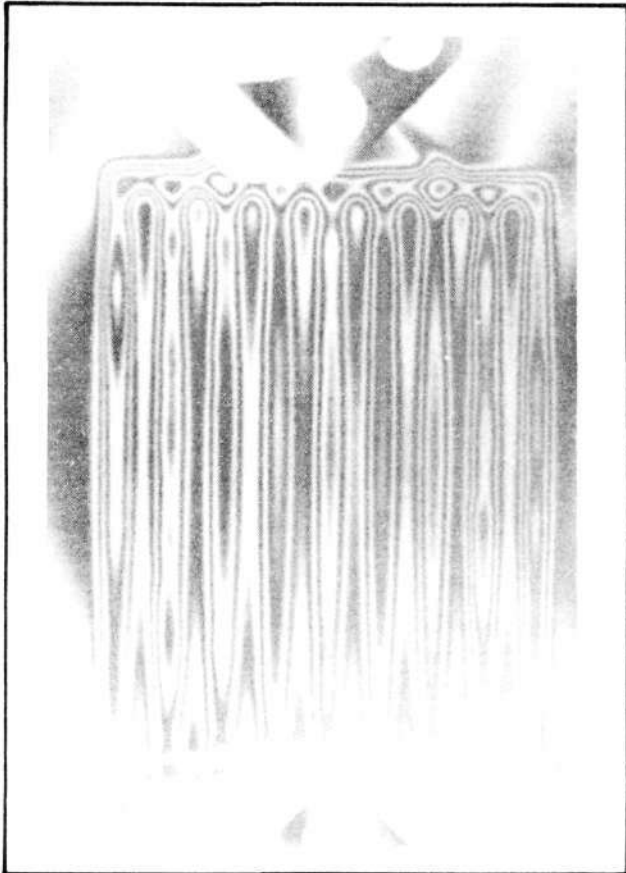
TEST RESULTS ON ELECTROFORMED WEAK BOND PANEL NO. 5

FIGURE A-8

# ELECTROFORM CONT'D

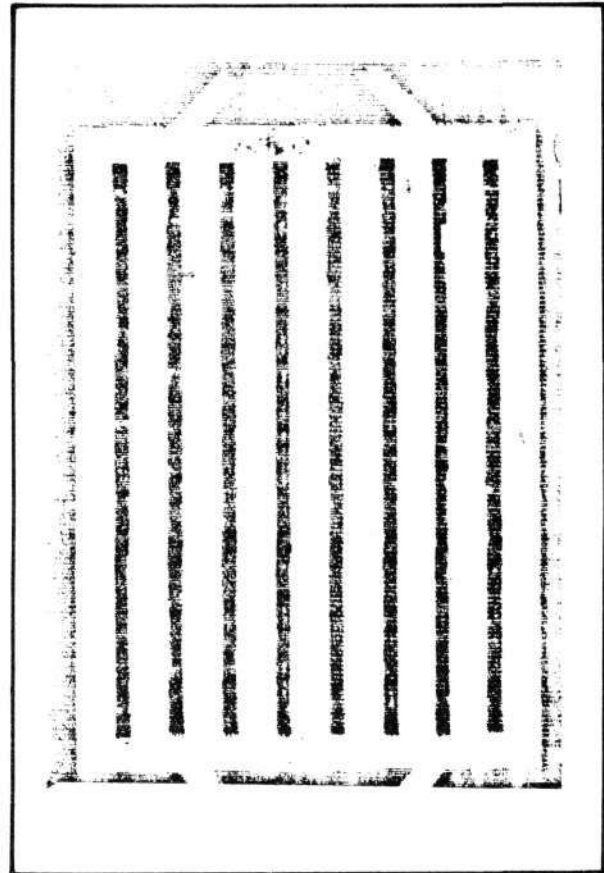


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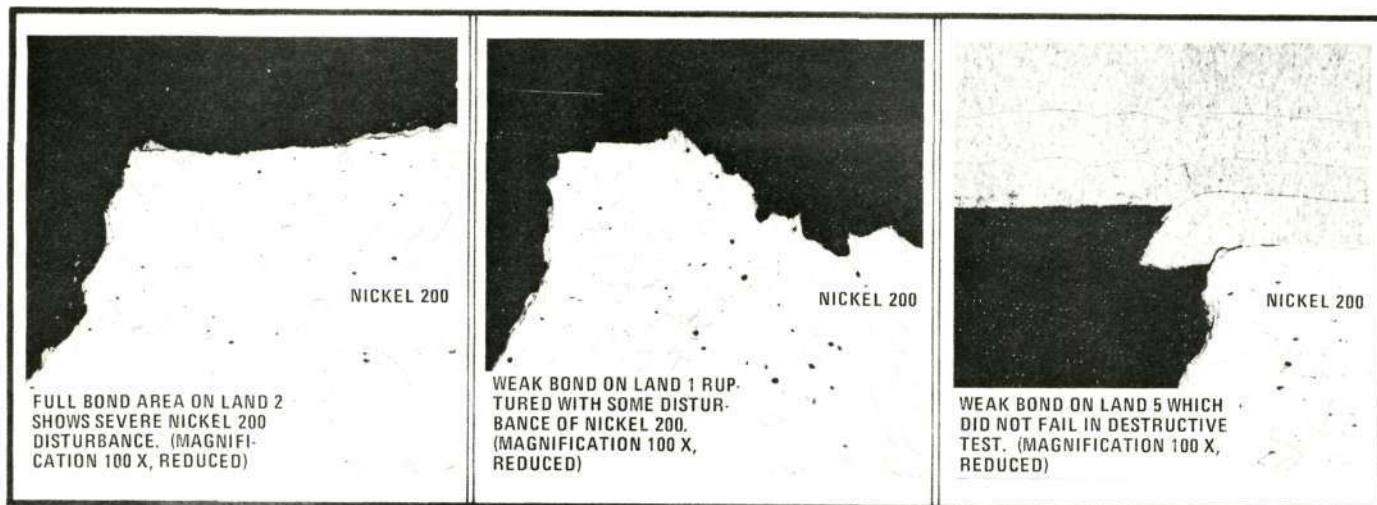


TEST PRESSURE - 500 PSI

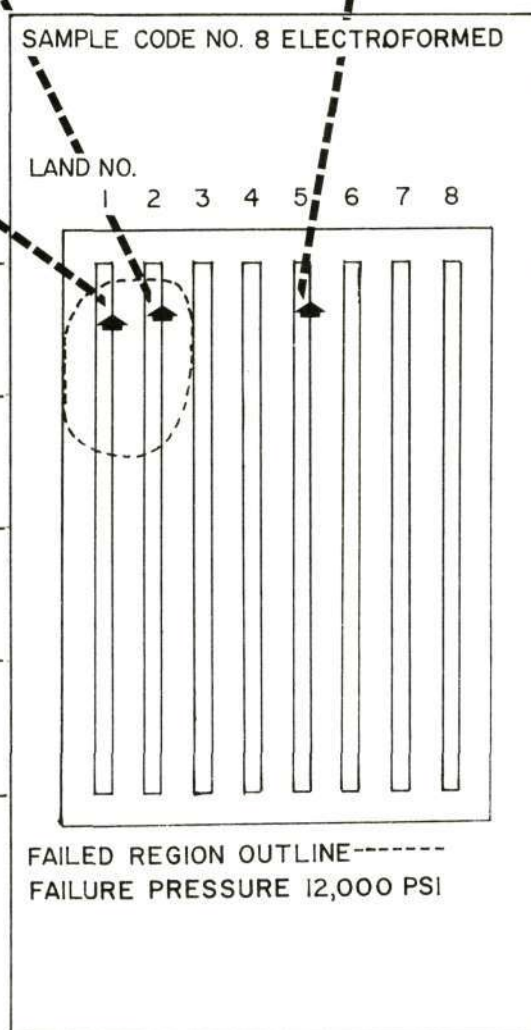
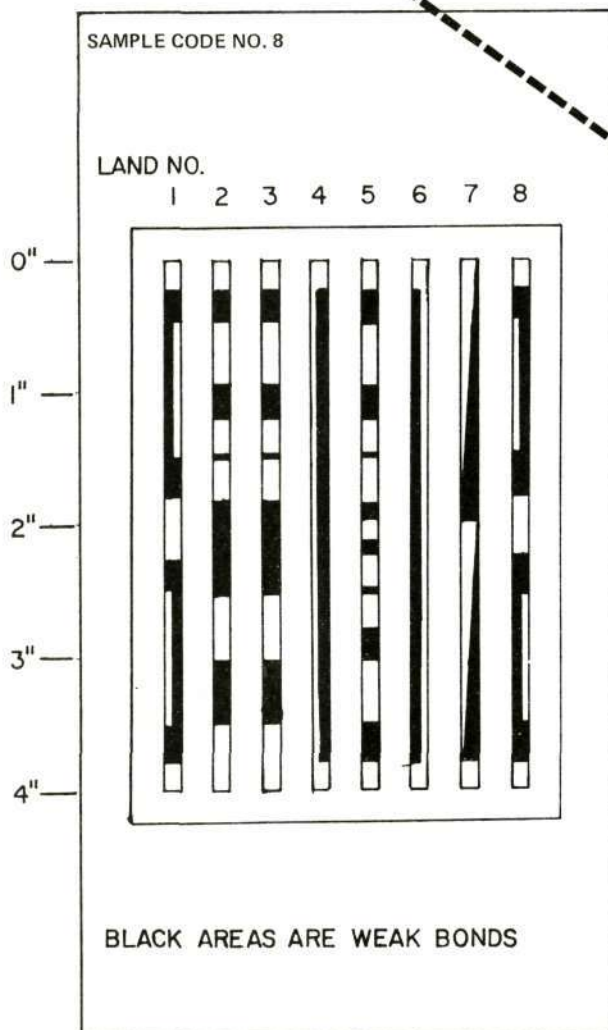
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# ELECTROFORMED WEAK BONDS - PATTERN 2



TEST RESULTS ON ELECTROFORMED WEAK BOND PANEL NO. 8

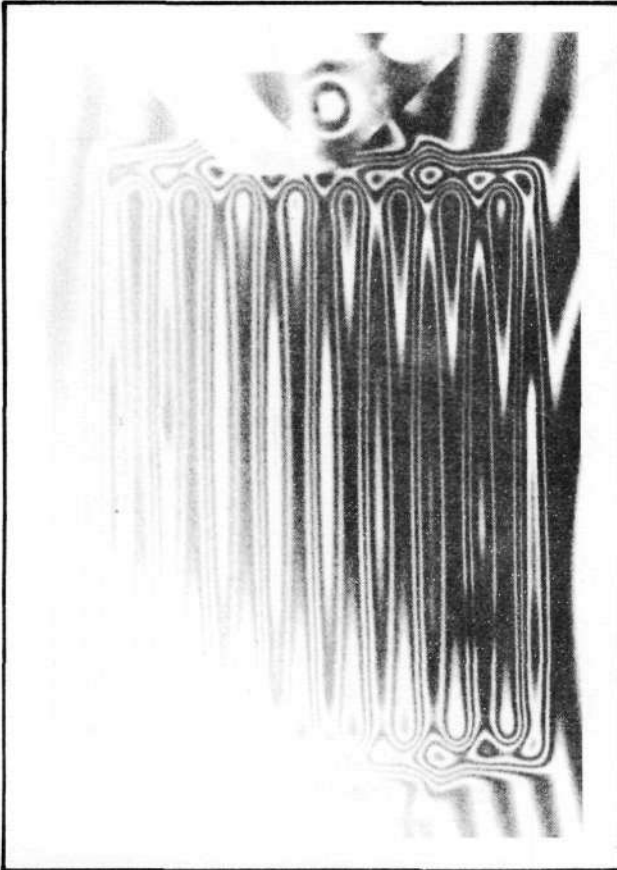
FIGURE A-9

ELECTROFORM CONT'D

8

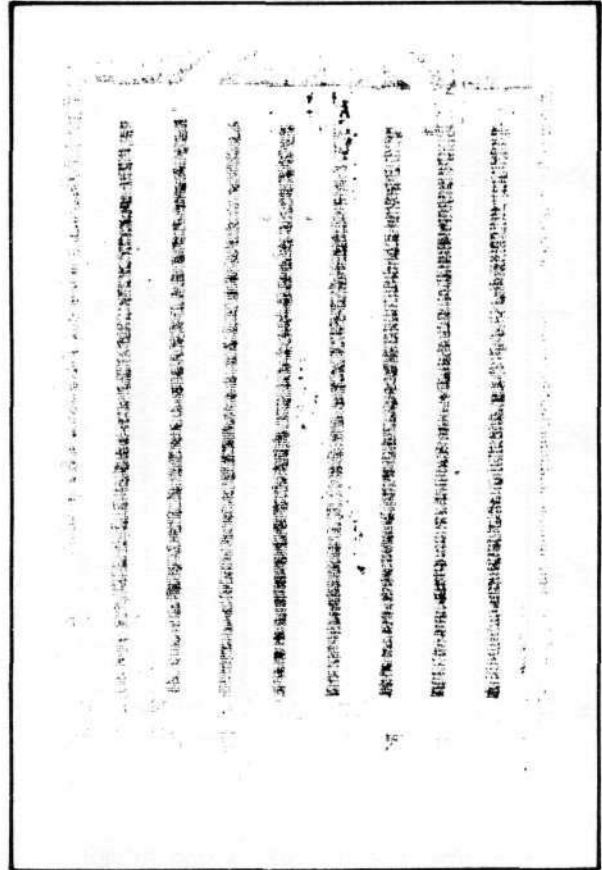
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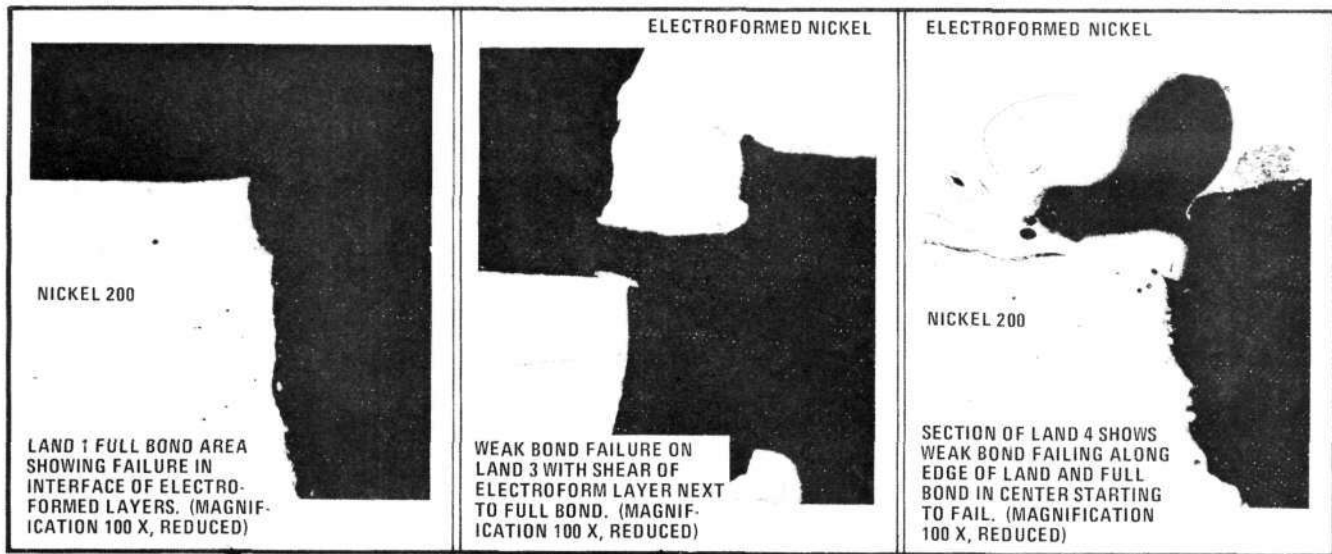
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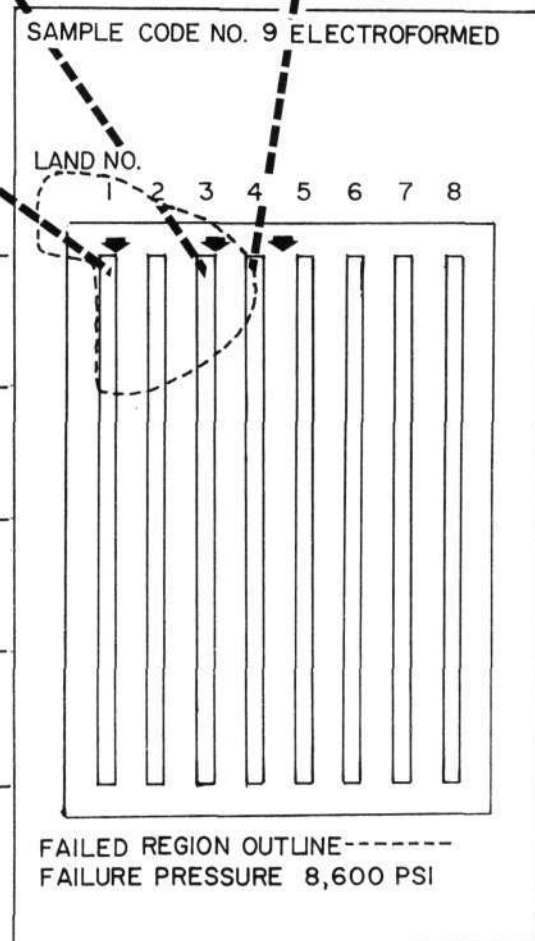
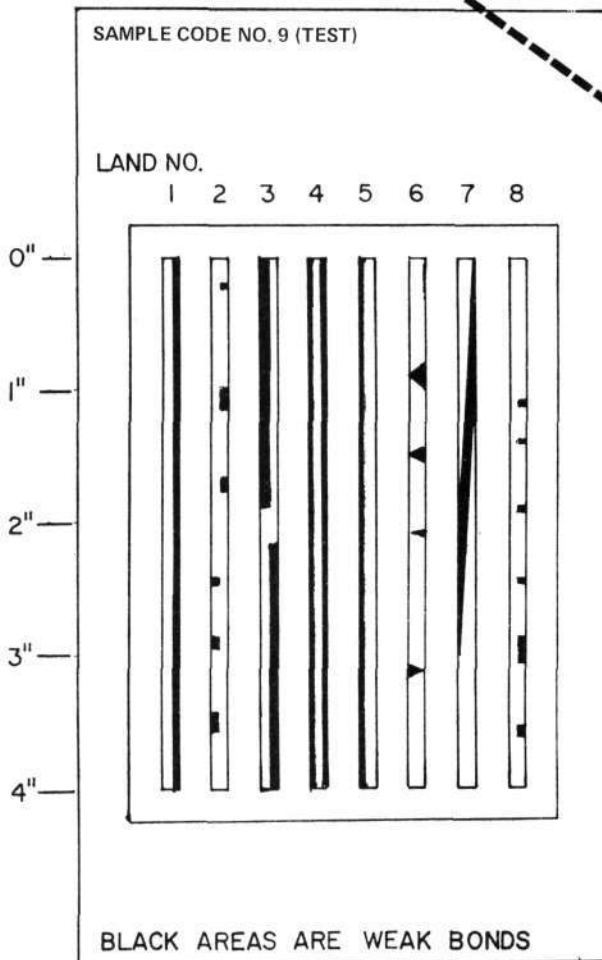
TEST PRESSURE - 500 PSI

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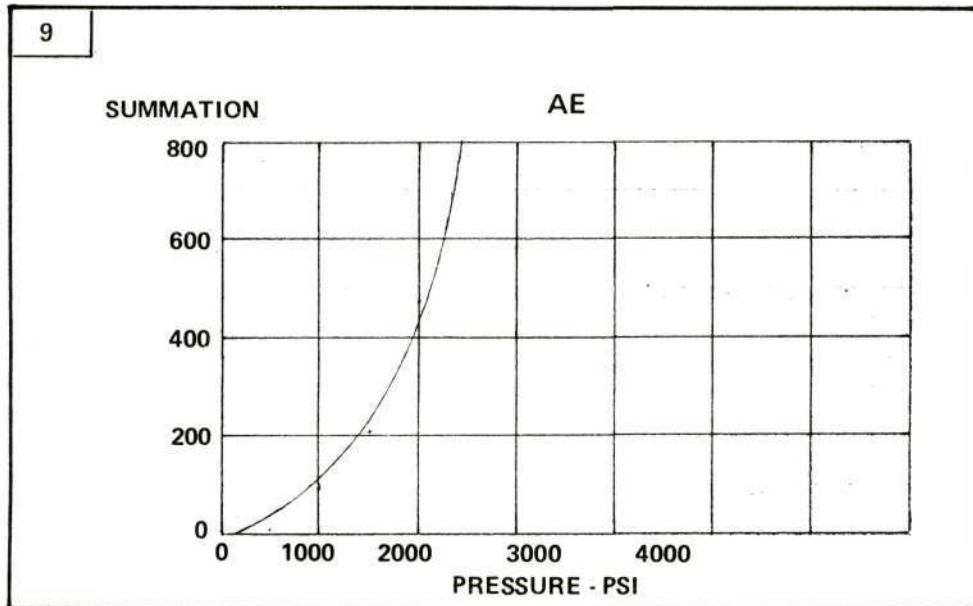
ELECTROFORMED WEAK BONDS - PATTERN 3



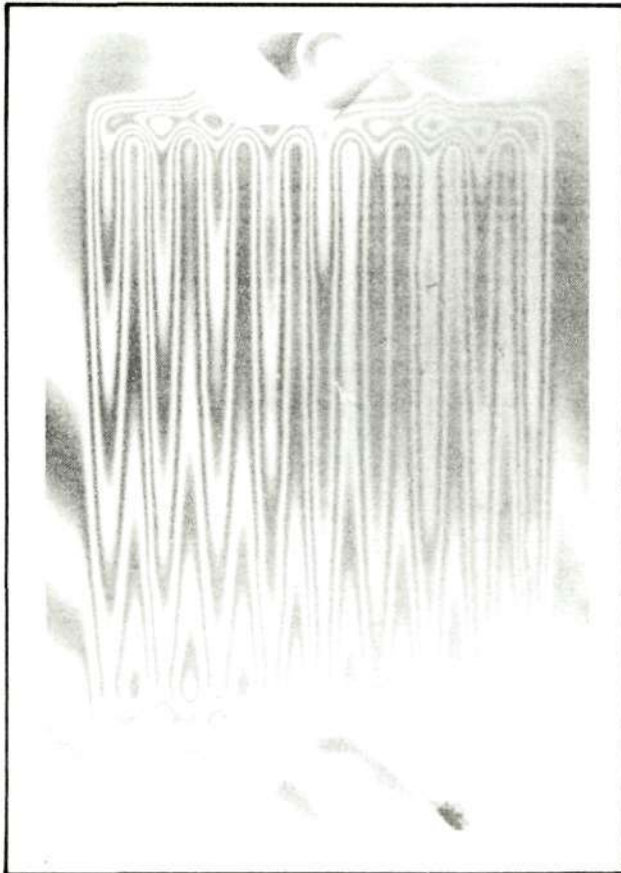
TEST RESULTS ON ELECTROFORMED WEAK BOND PANEL NO. 9

FIGURE A-10

# ELECTROFORM CONT'D

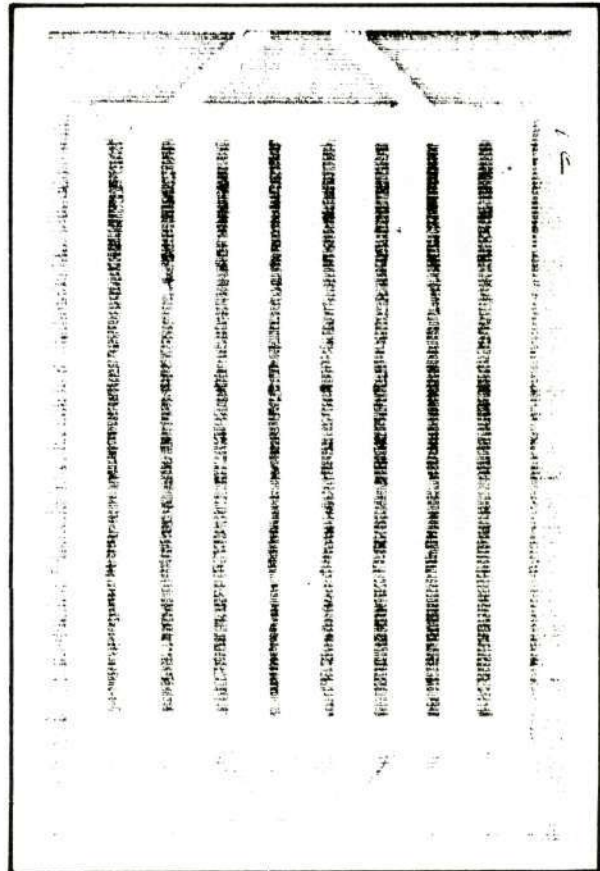


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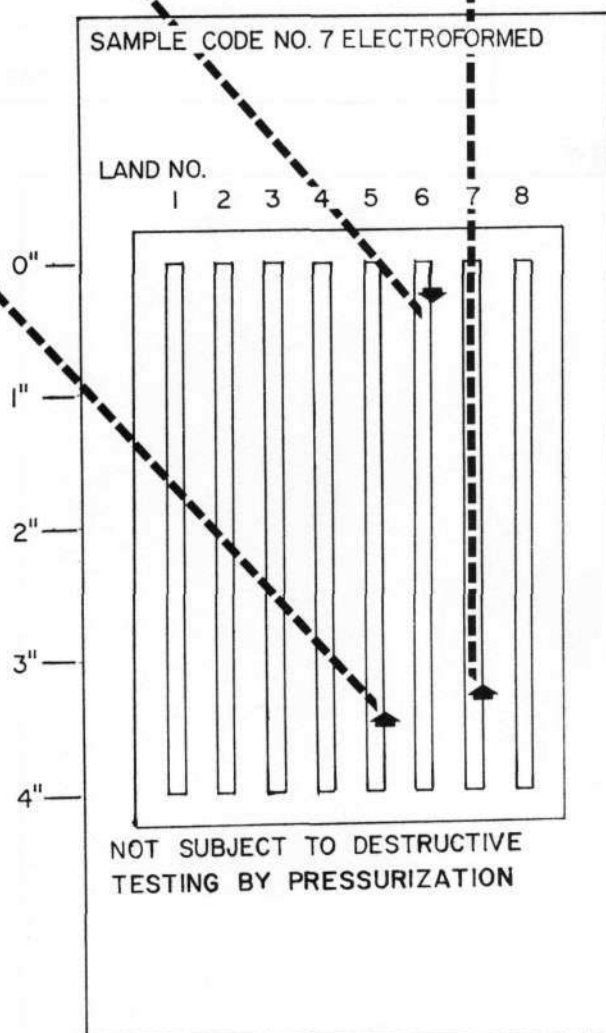
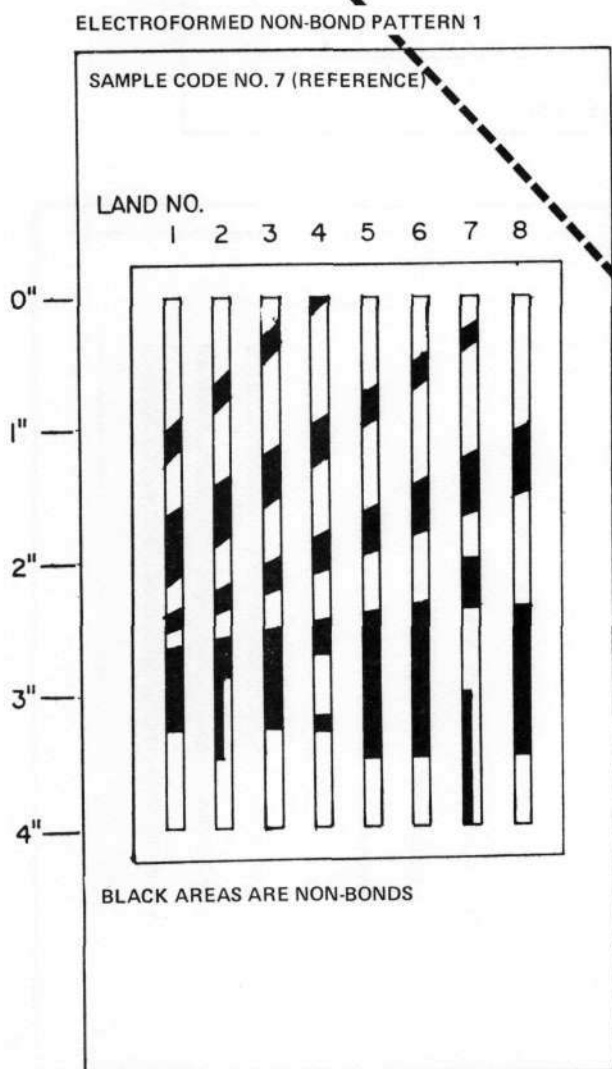
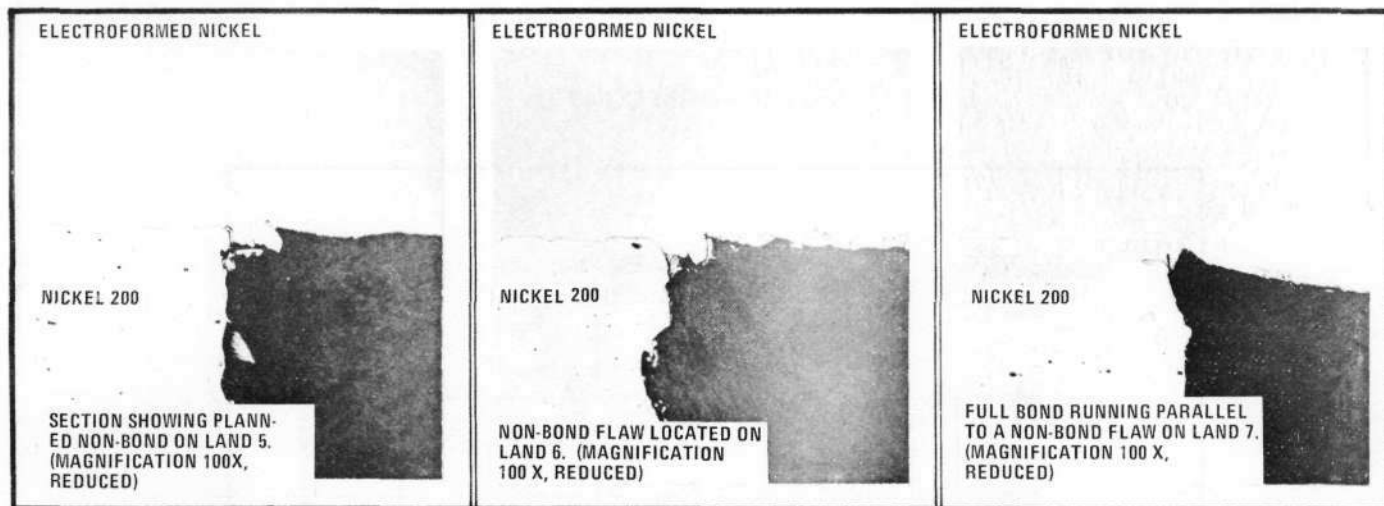


TEST PRESSURE - 500 PSI

UT





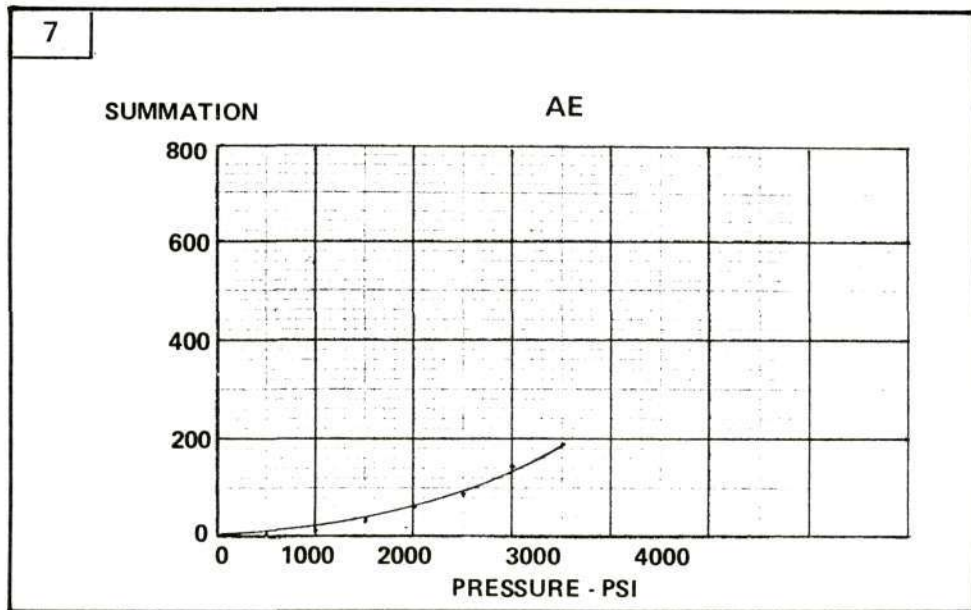


TEST RESULTS ON ELECTROFORMED NON-BOND PANEL NO. 7

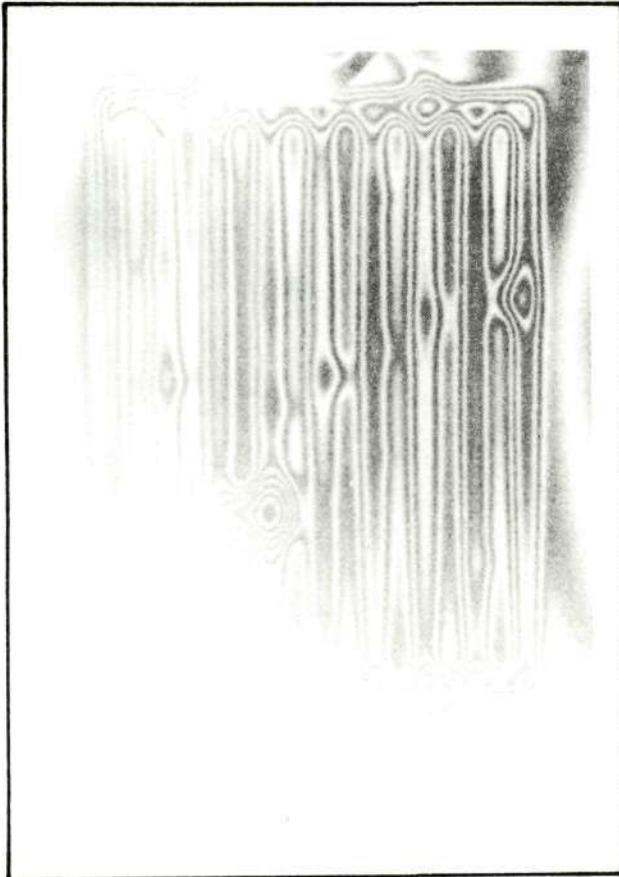
FIGURE A-11

# ELECTROFORM CONT'D

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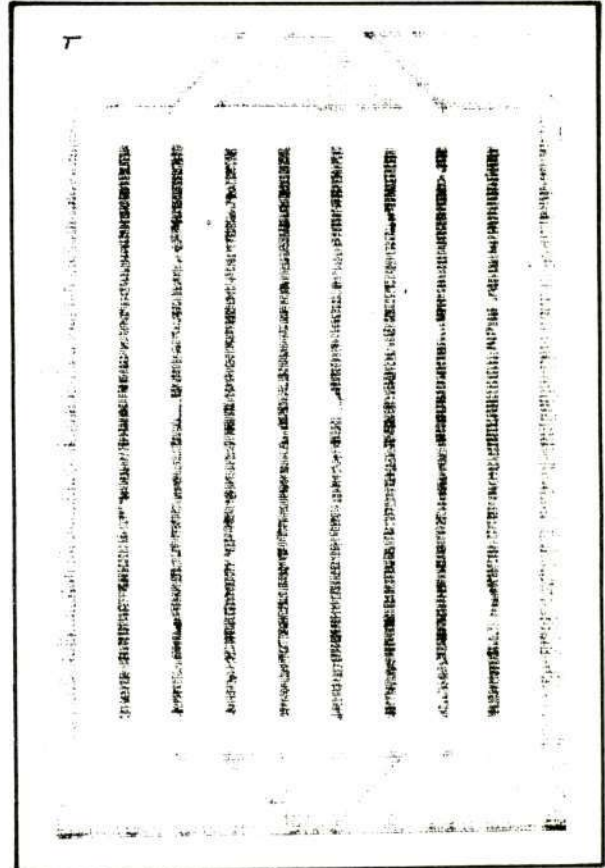


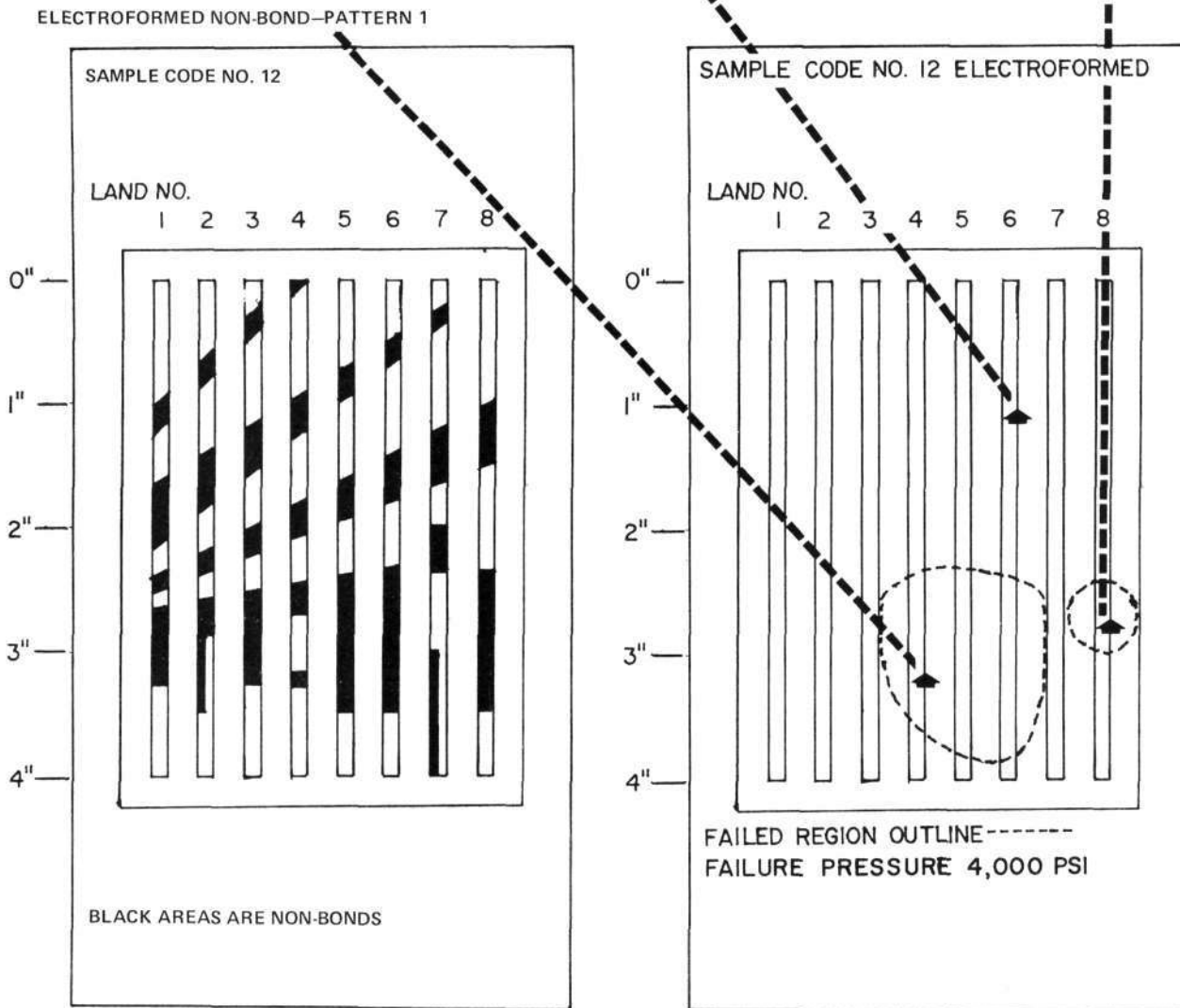
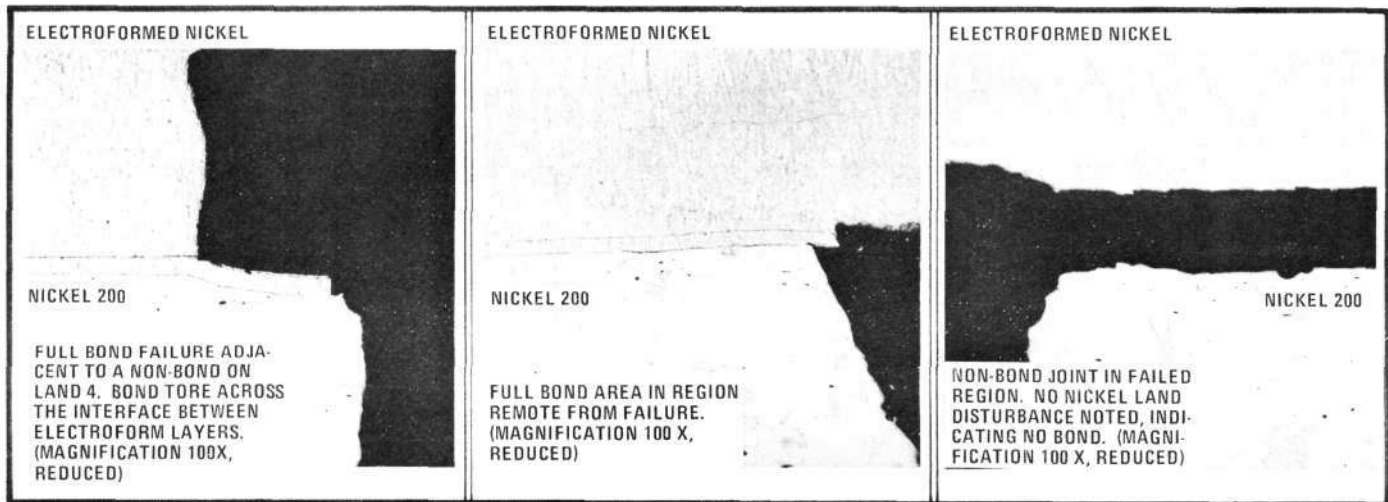
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TEST PRESSURE - 500 PSI

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TEST RESULTS FOR ELECTROFORMED NON-BOND PANEL NO. 12

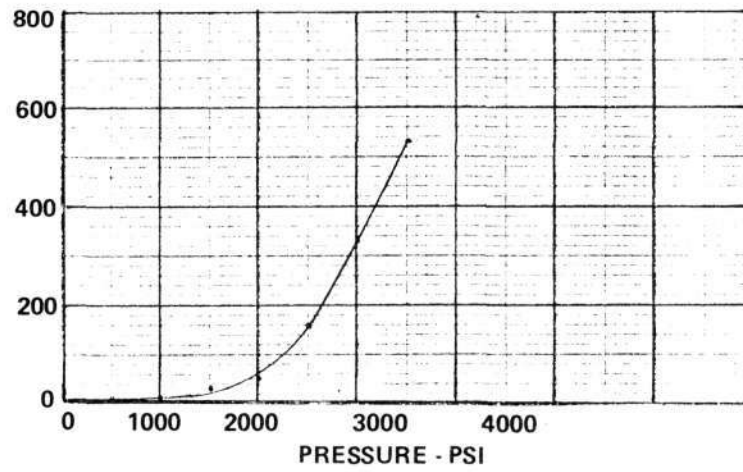
FIGURE A-12

# ELECTROFORM CONT'D

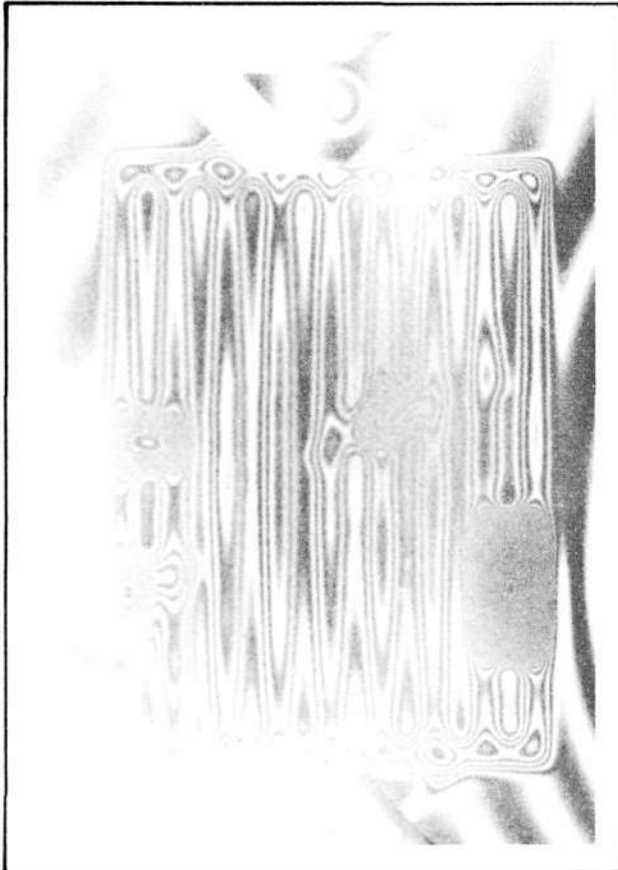
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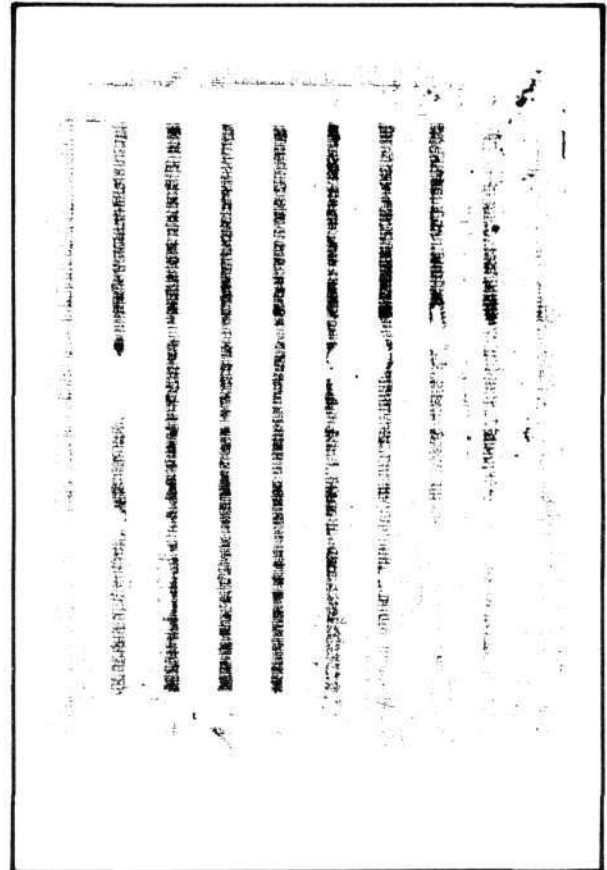
AE



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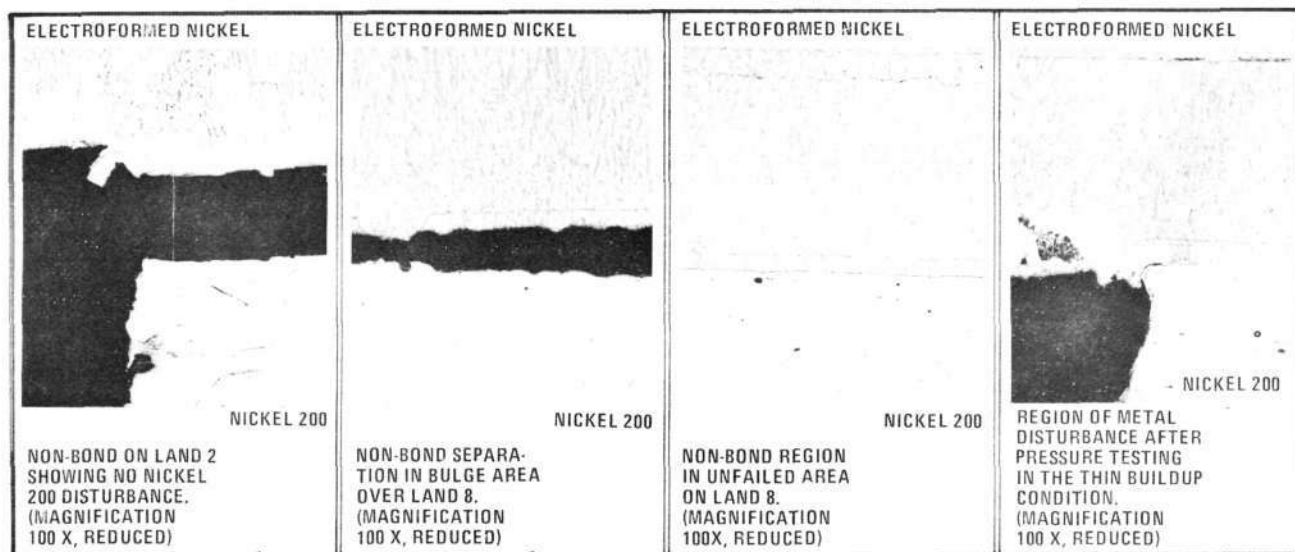


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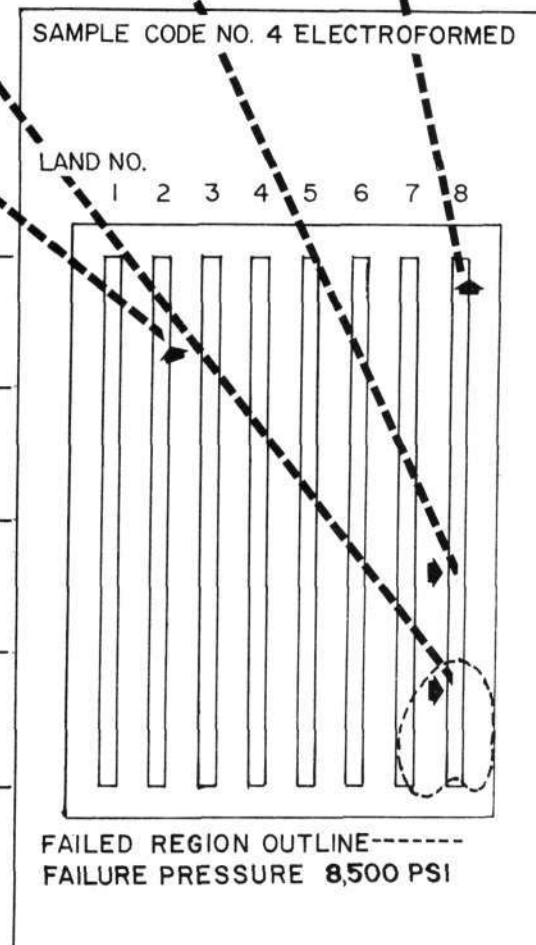
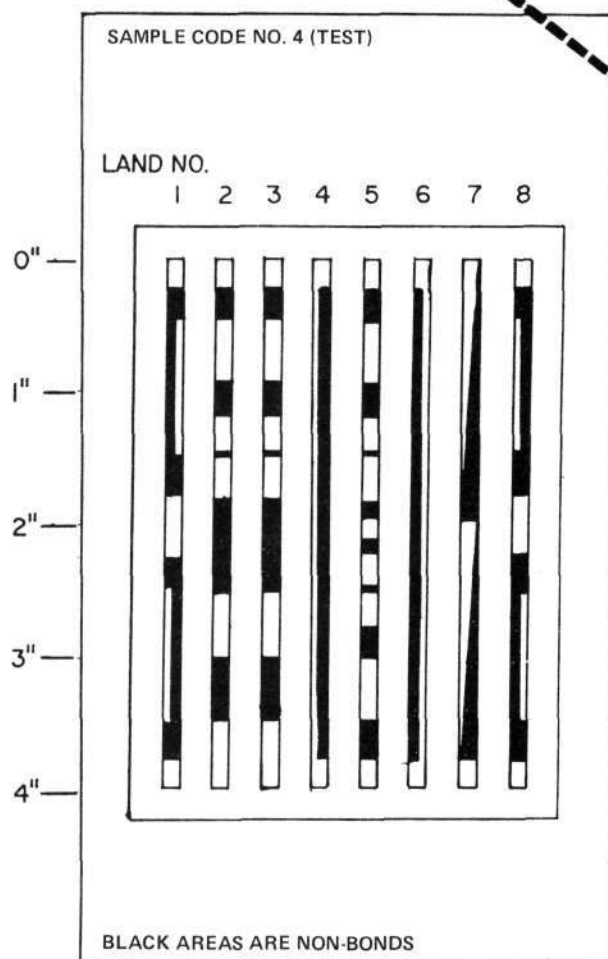


TEST PRESSURE - 500 PSI





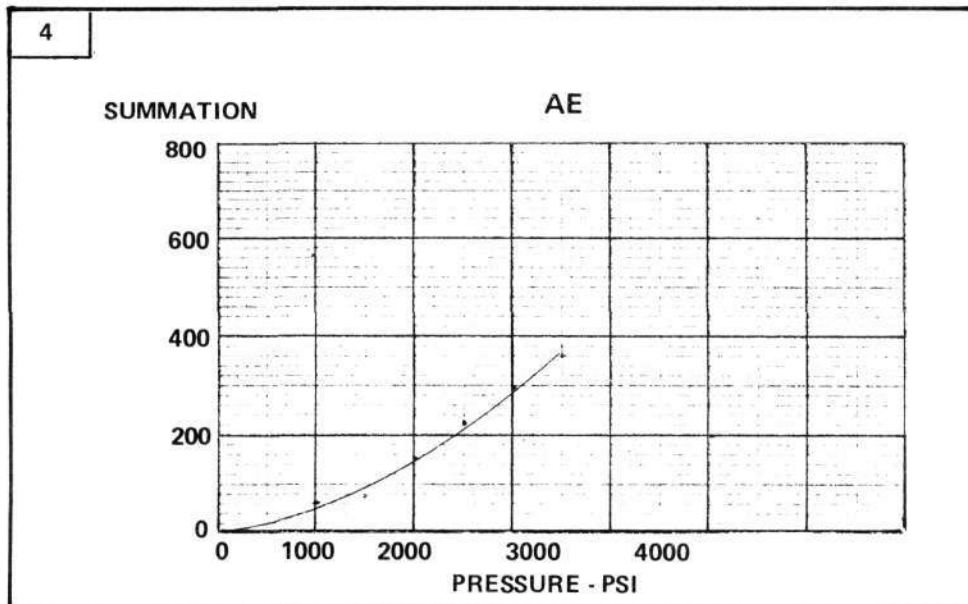
ELECTROFORMED NON-BONDS, PATTERN 3



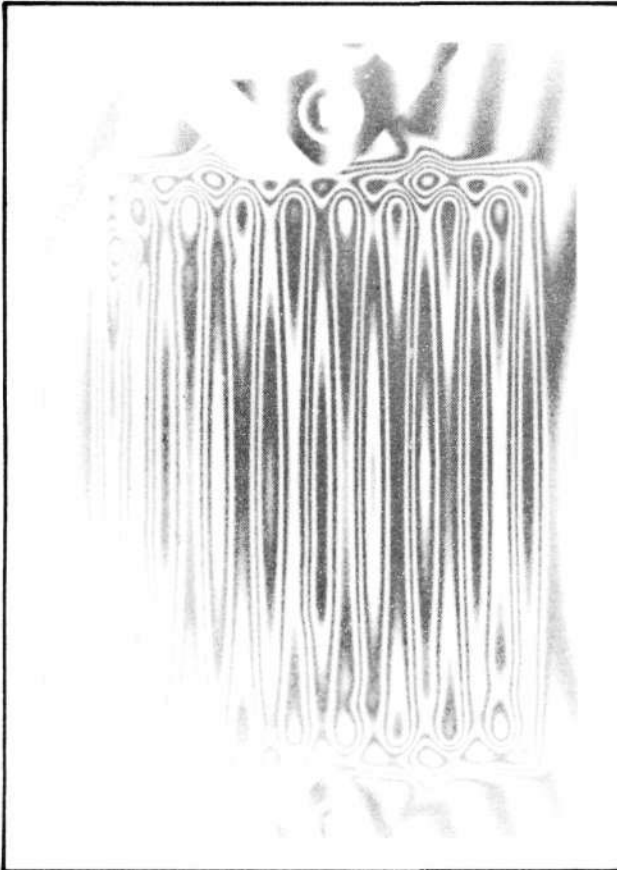
TEST RESULTS ON ELECTROFORMED NON-BOND PANEL NO. 4

FIGURE A-13

# ELECTROFORM CONT'D

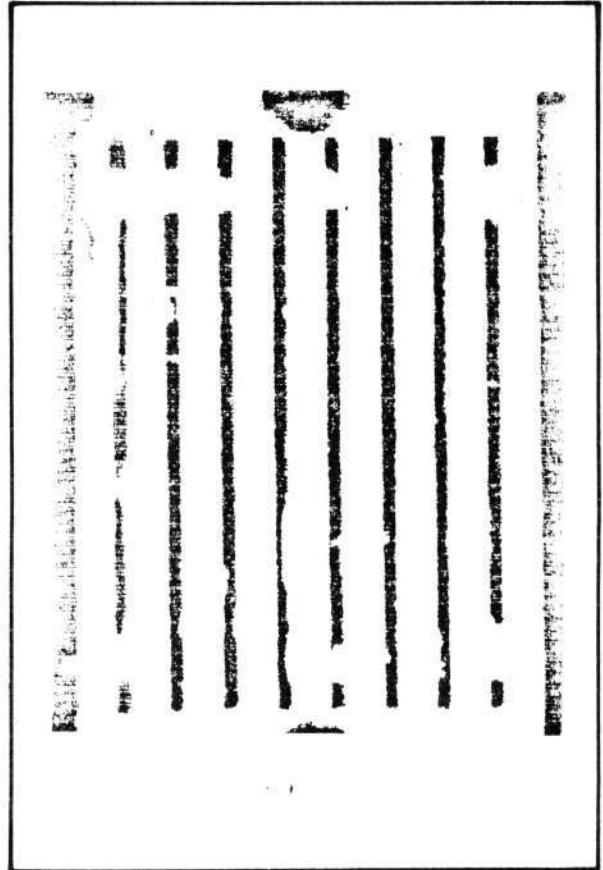


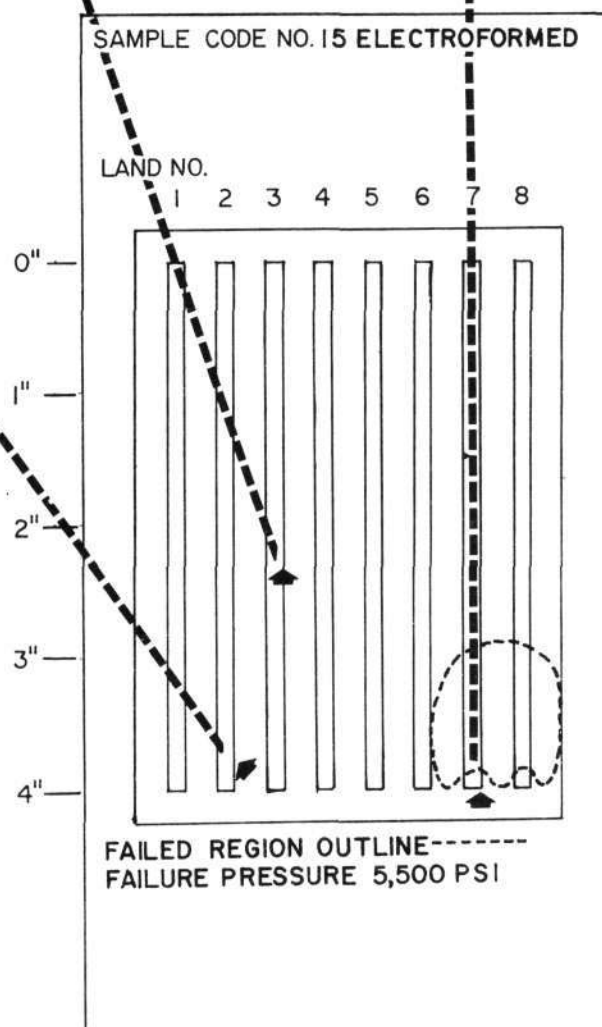
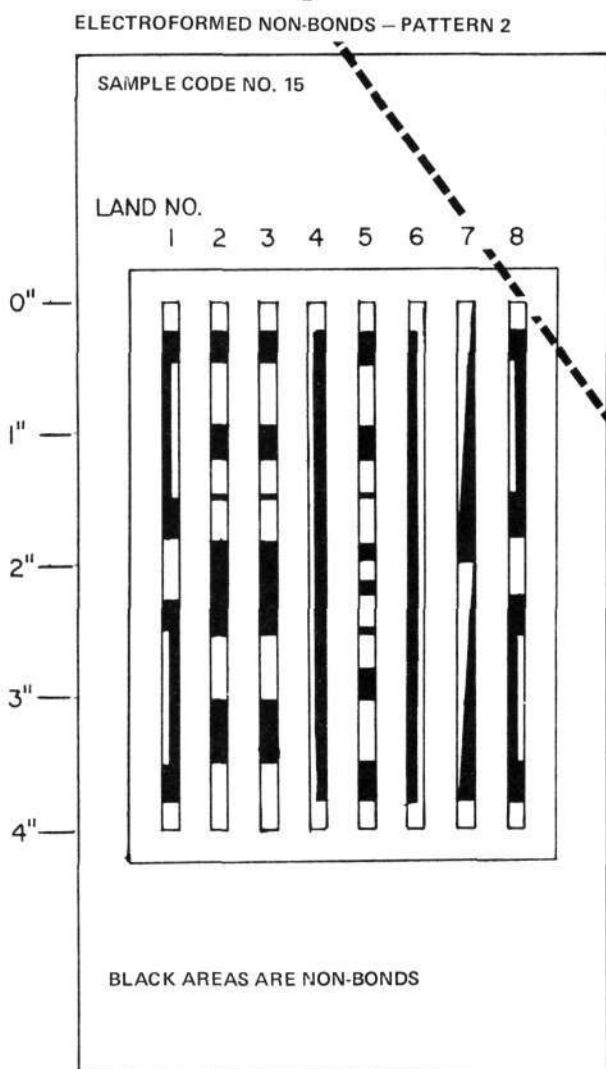
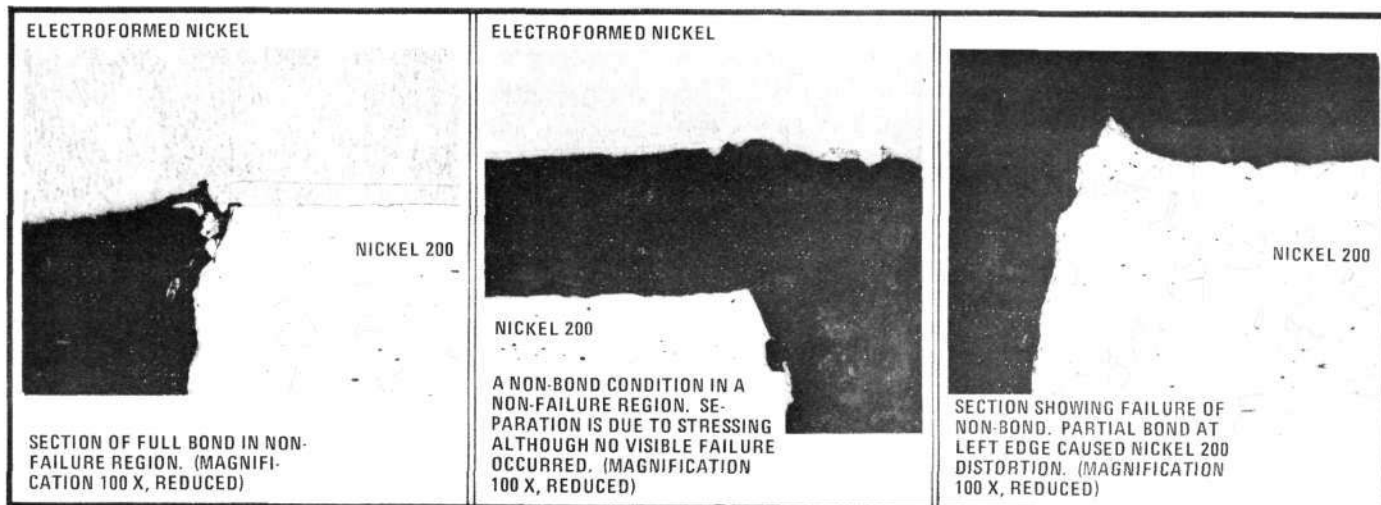
HNDT



TEST PRESSURE - 500 PSI

UT





TEST RESULTS FOR ELECTROFORMED NON-BOND PANEL NO. 15

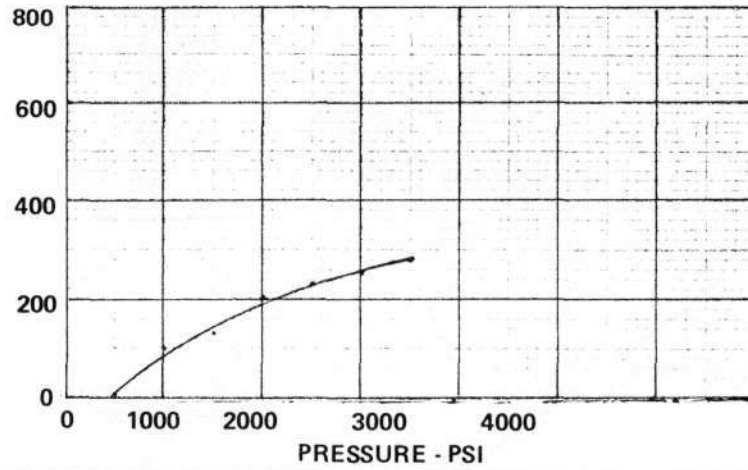
FIGURE A-14

# ELECTROFORM CONT'D

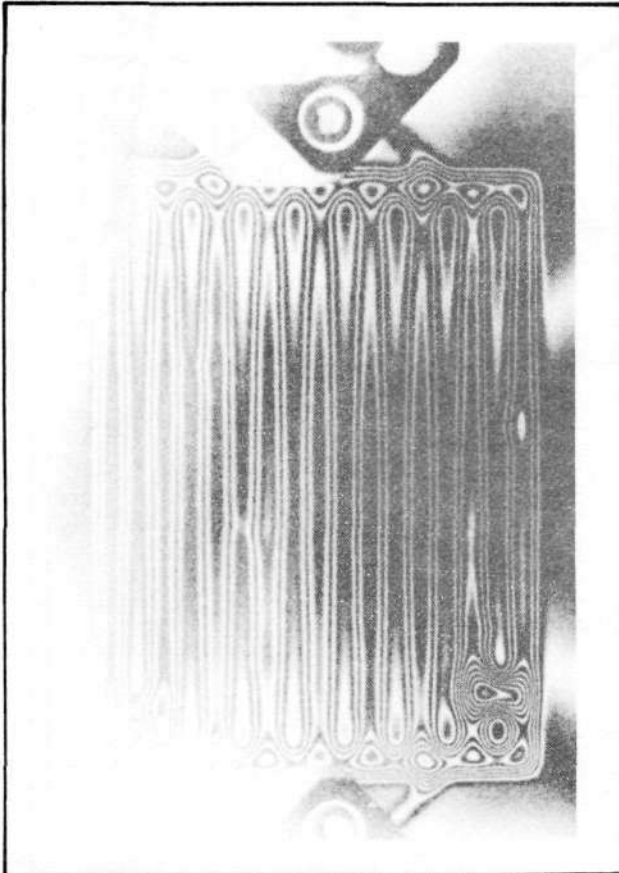
15

SUMMATION

AE

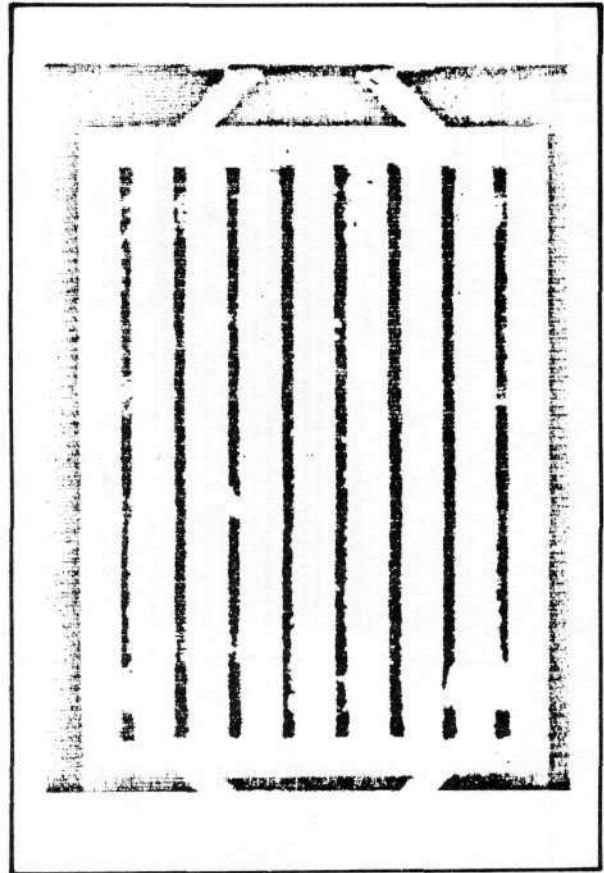


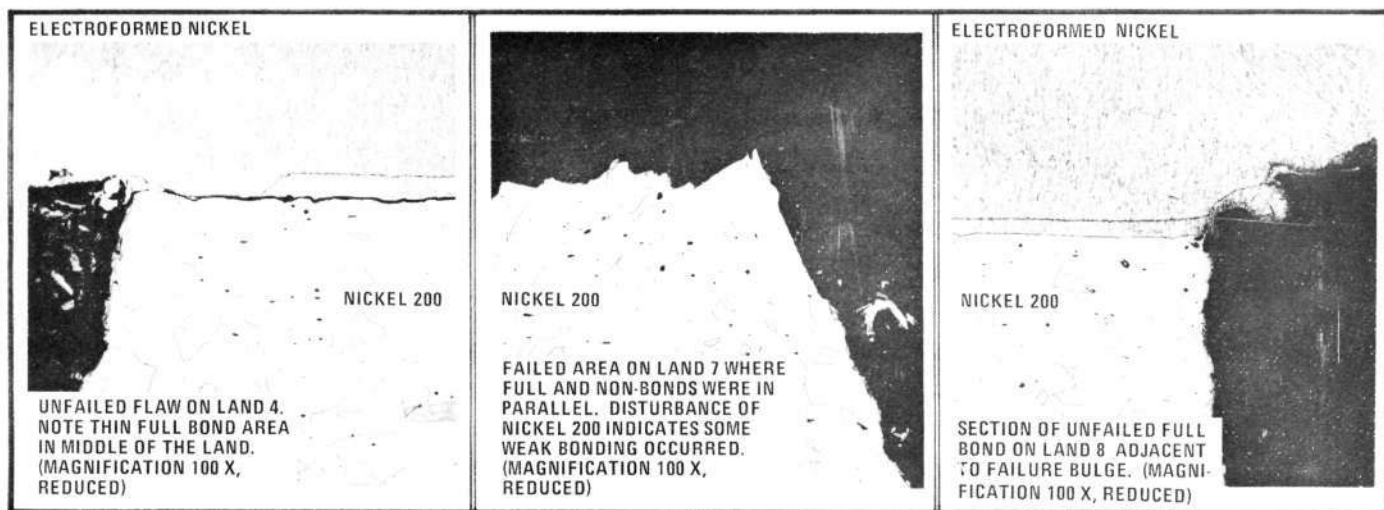
HNDT



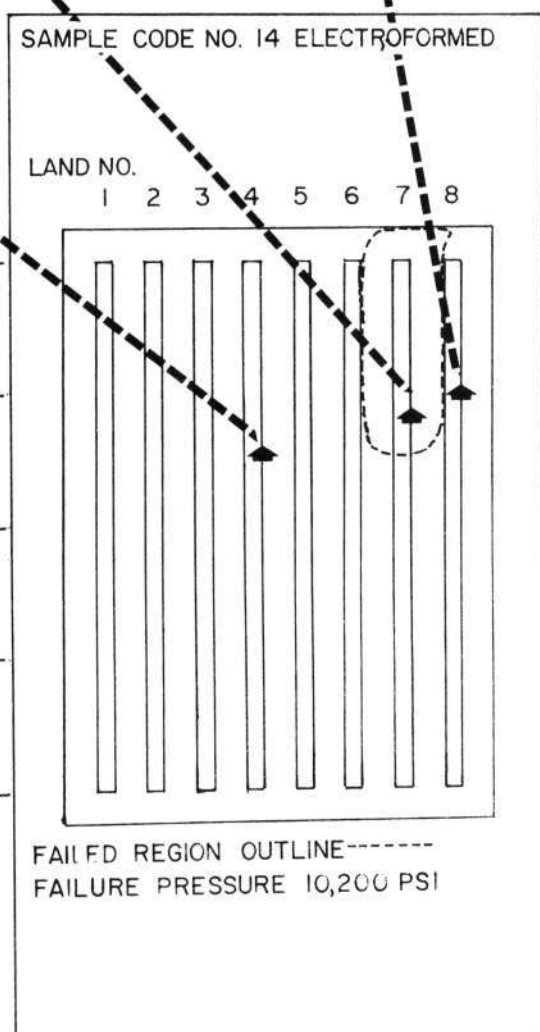
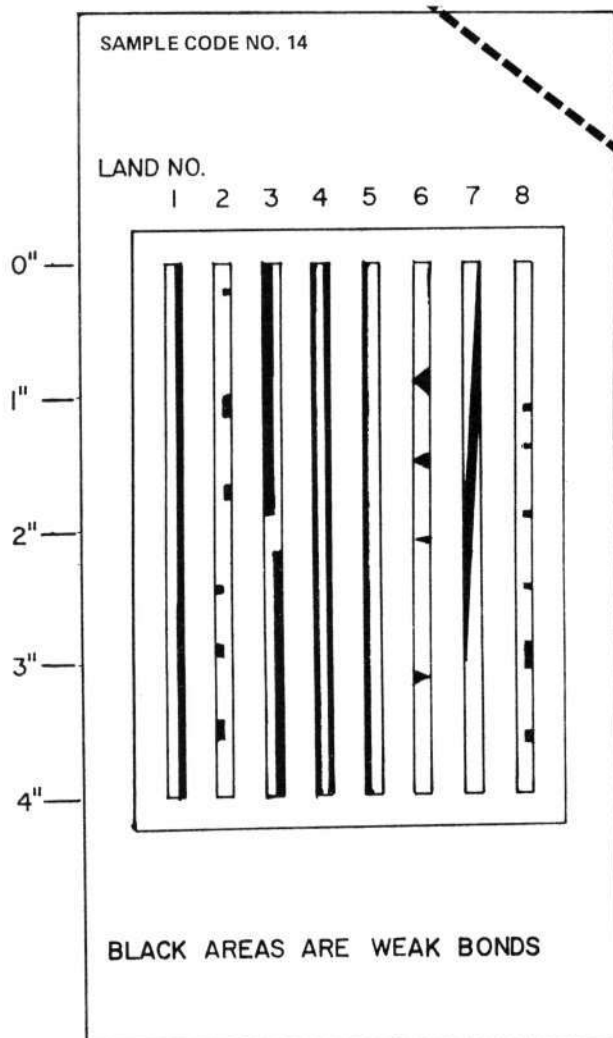
TEST PRESSURE - 500 PSI

UT





**ELECTROFORMED NON-BONDS - PATTERN 3**



**TEST RESULTS ON ELECTROFORMED NON-BOND PANEL NO. 14**

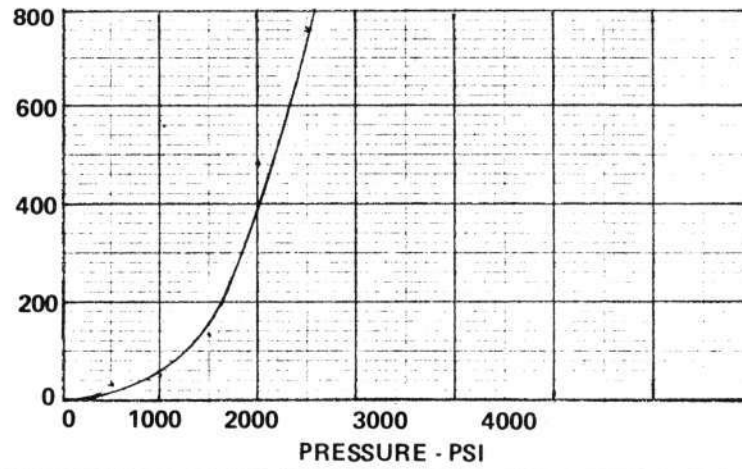
**FIGURE A-15**

# ELECTROFORM CONT'D

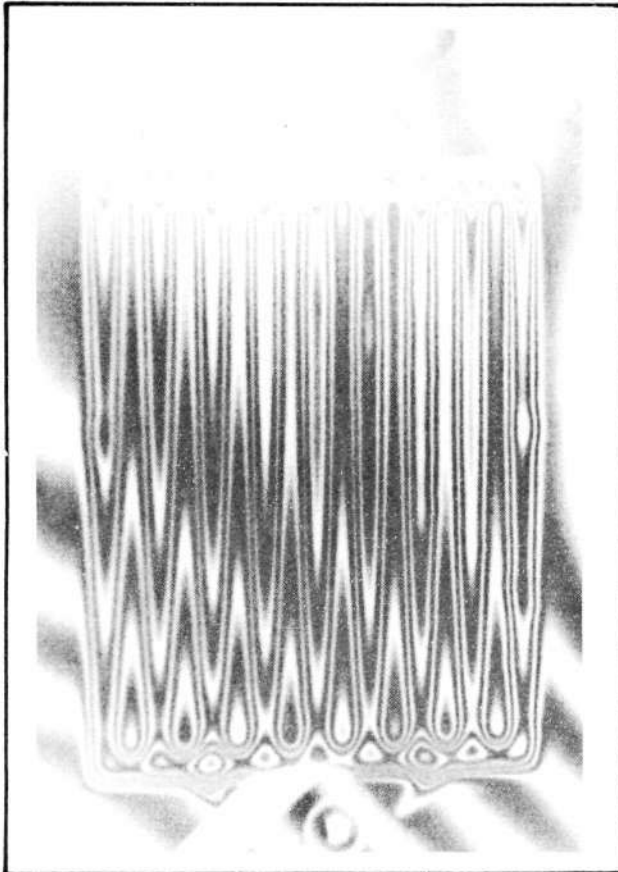
14

SUMMATION

AE

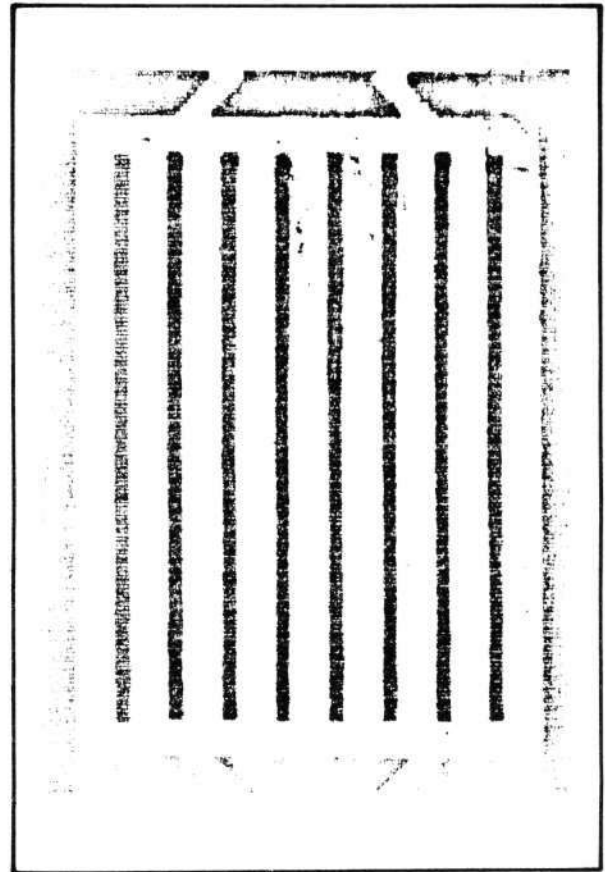


HNDT

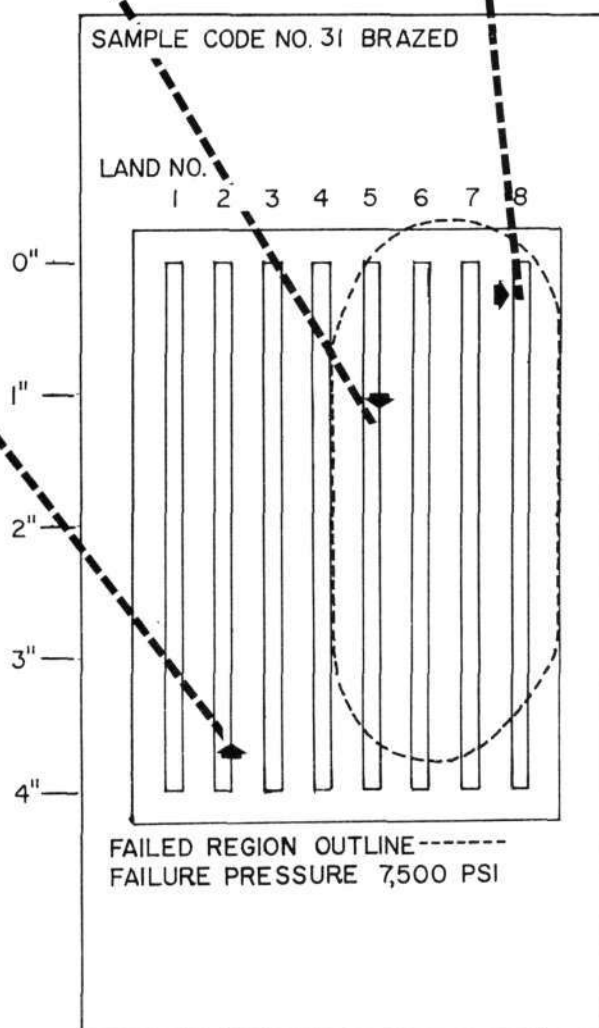
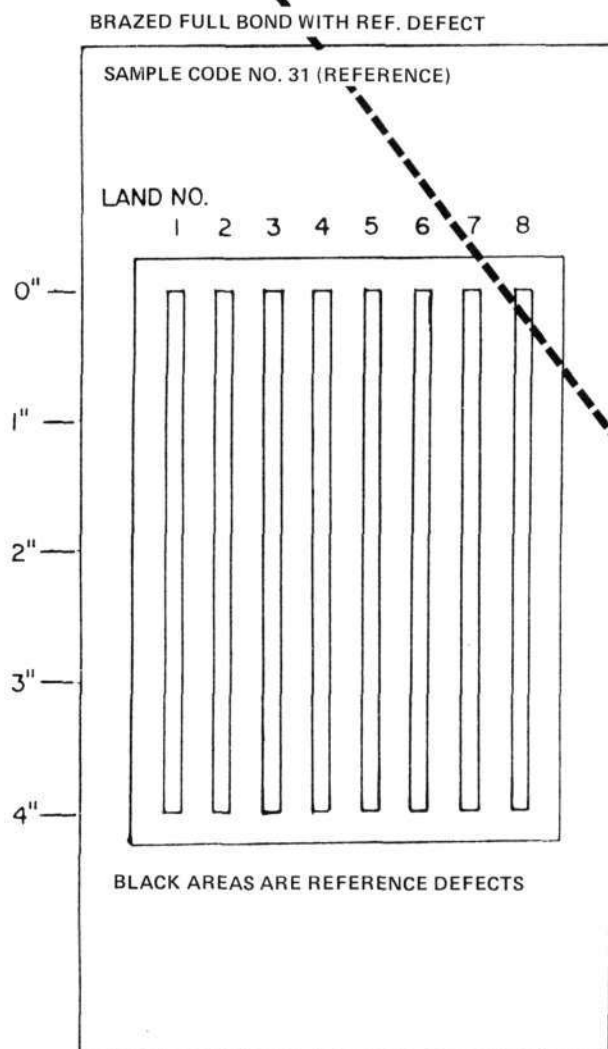
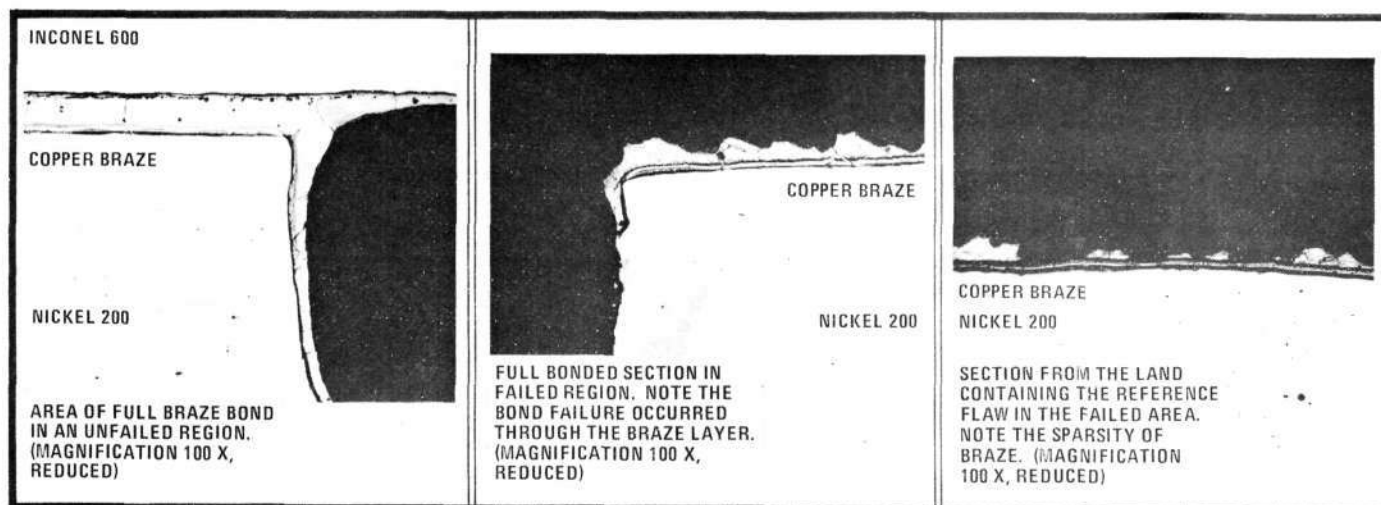


TEST PRESSURE - 500 PSI

UT







TEST RESULTS ON BRAZED FULL BOND PANEL NO. 31

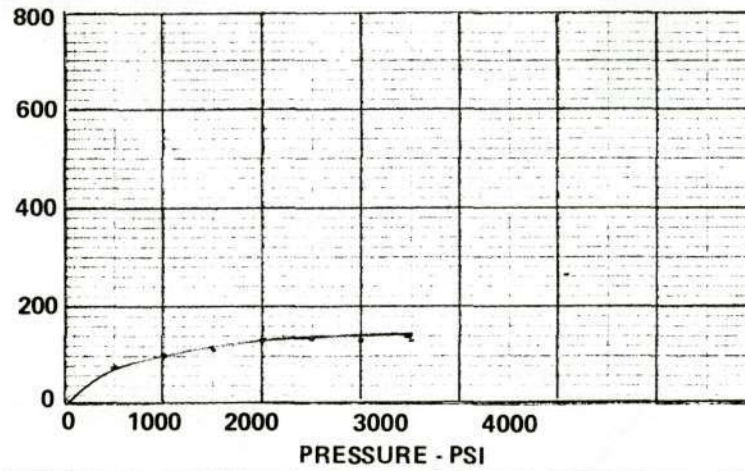
FIGURE A-16



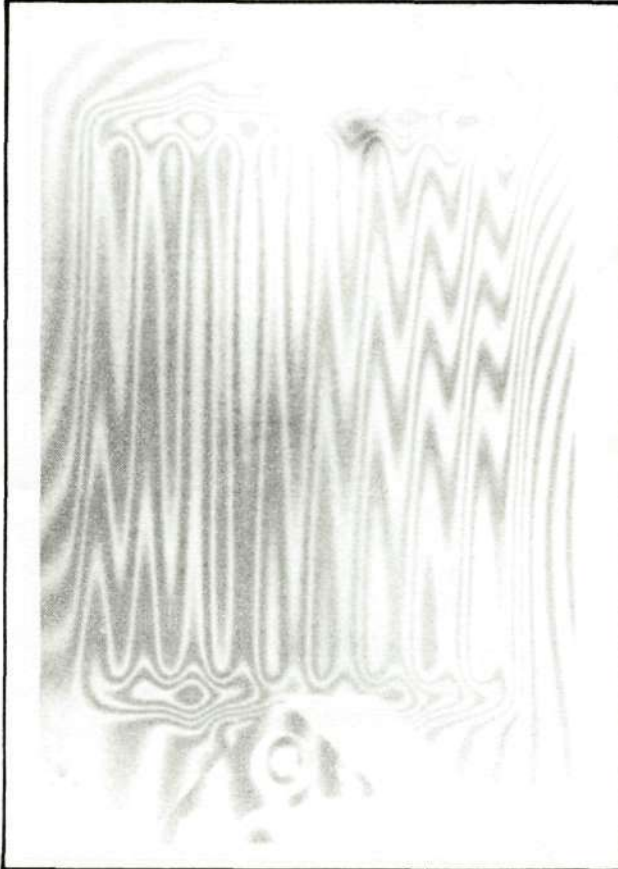
31

SUMMATION

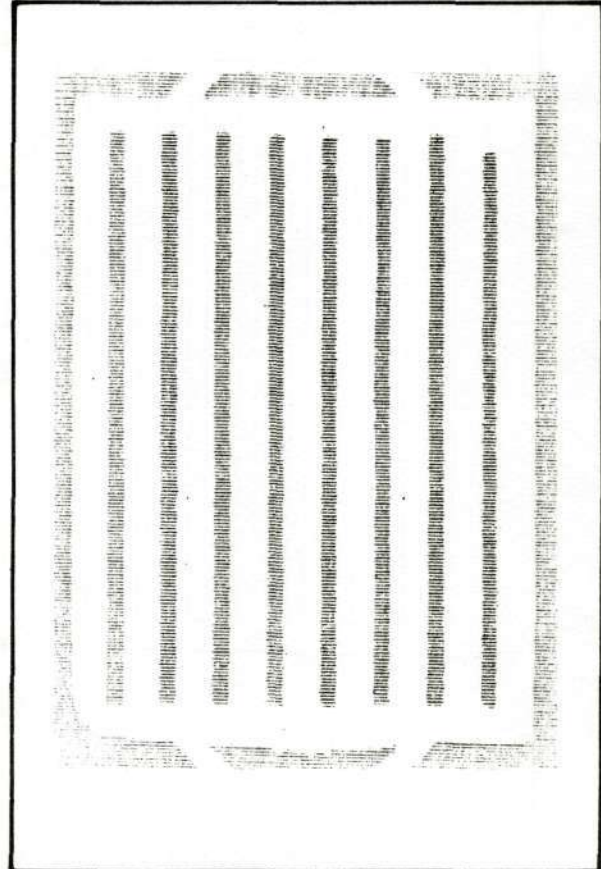
AE



HNDT

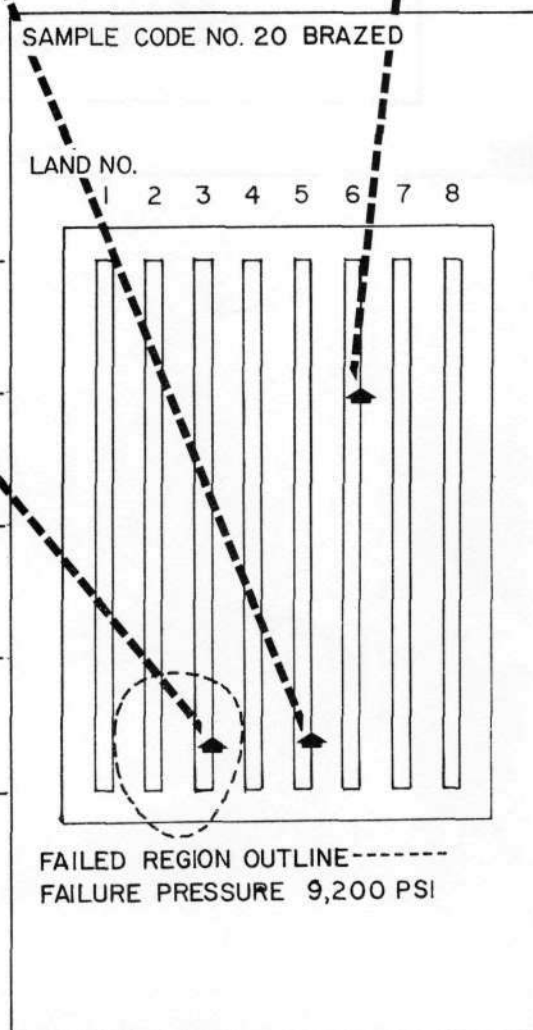
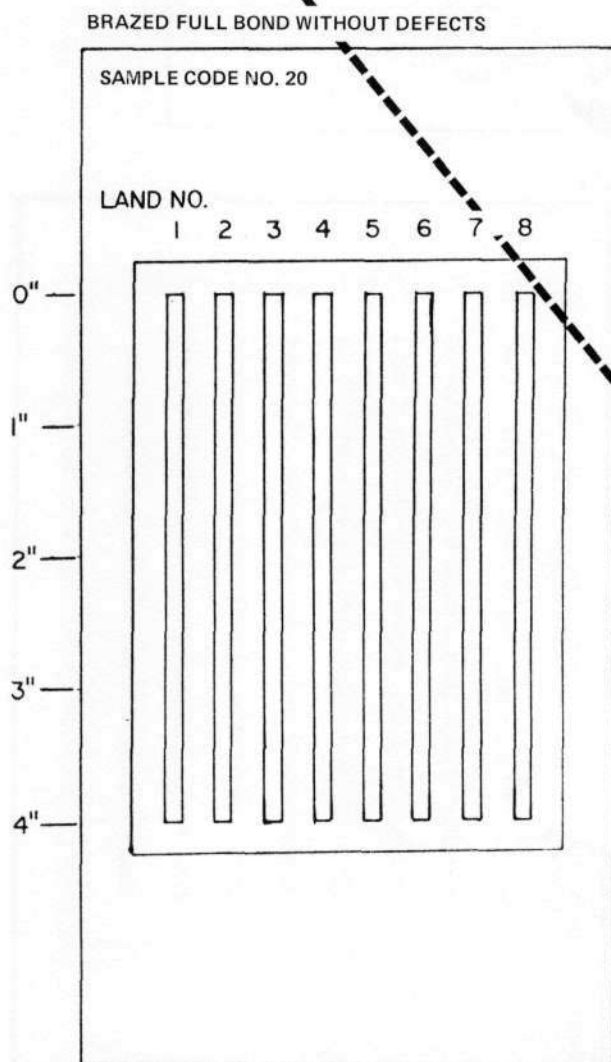
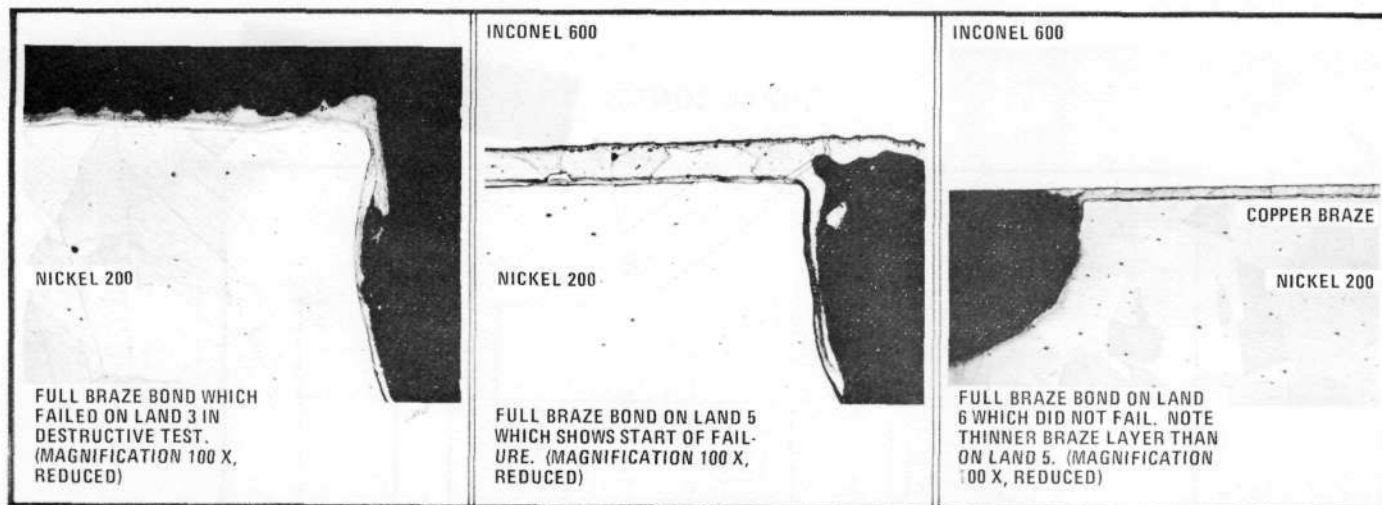


UT



TEST PRESSURE 1420 PSI

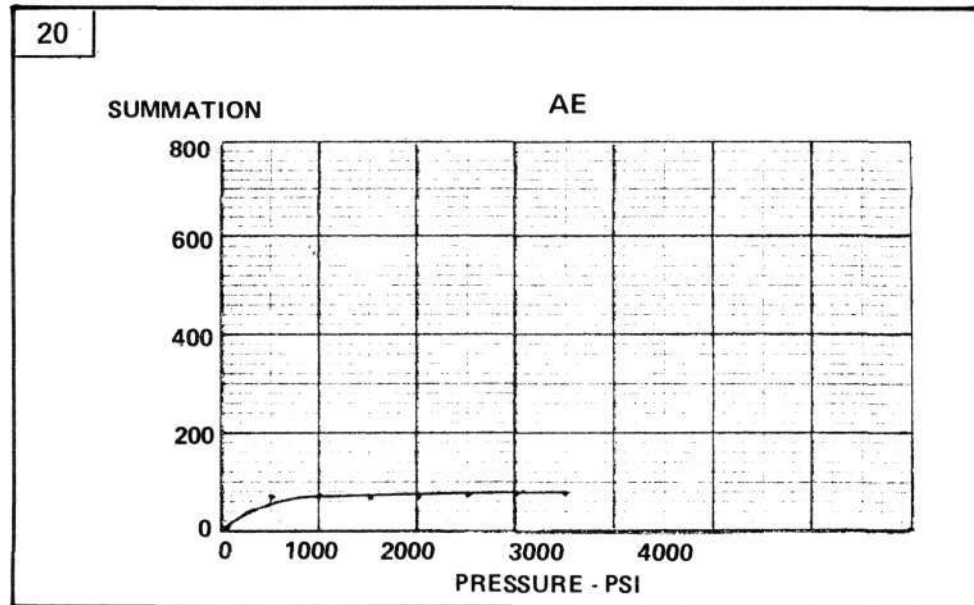




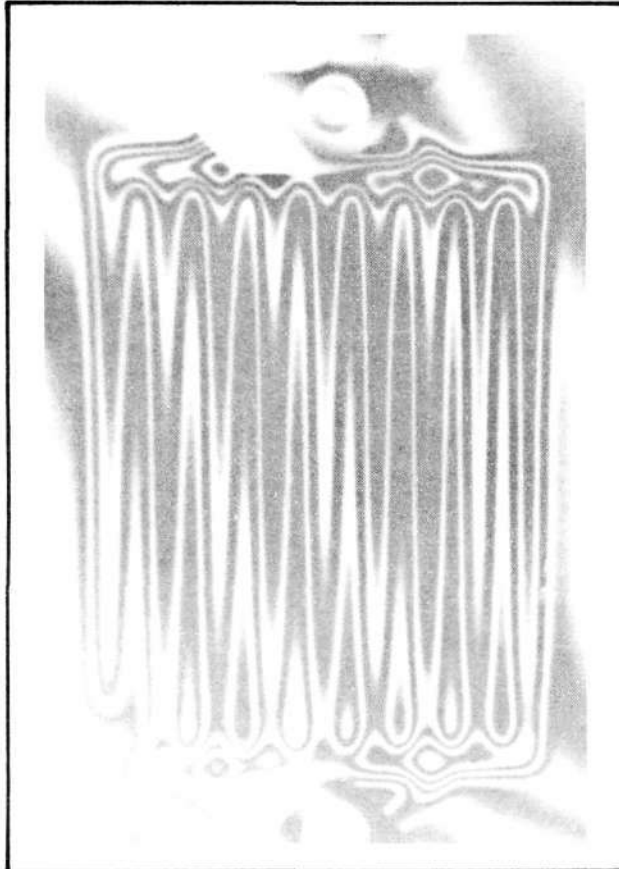
TEST RESULTS ON BRAZED FULL BOND PANEL NO. 20

FIGURE A-17

BRAZE CONT'D

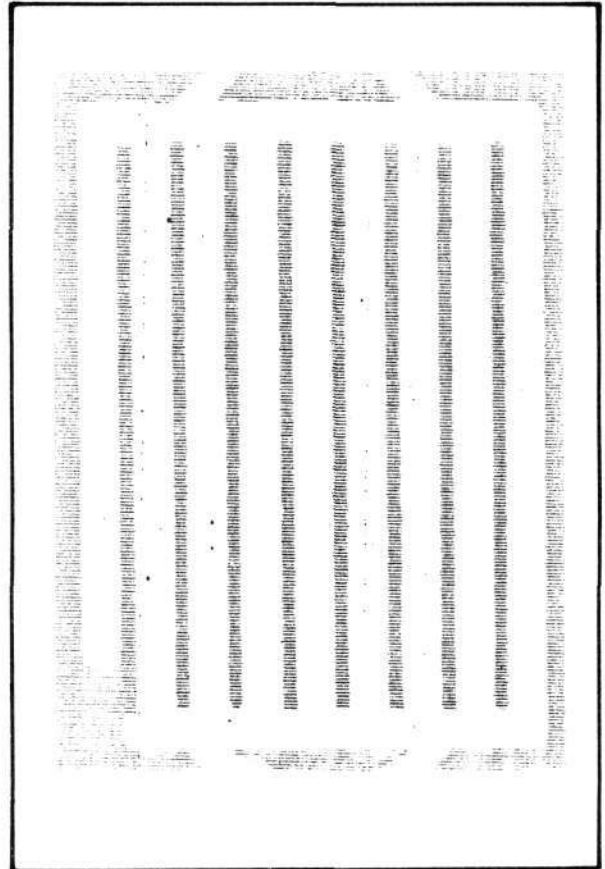


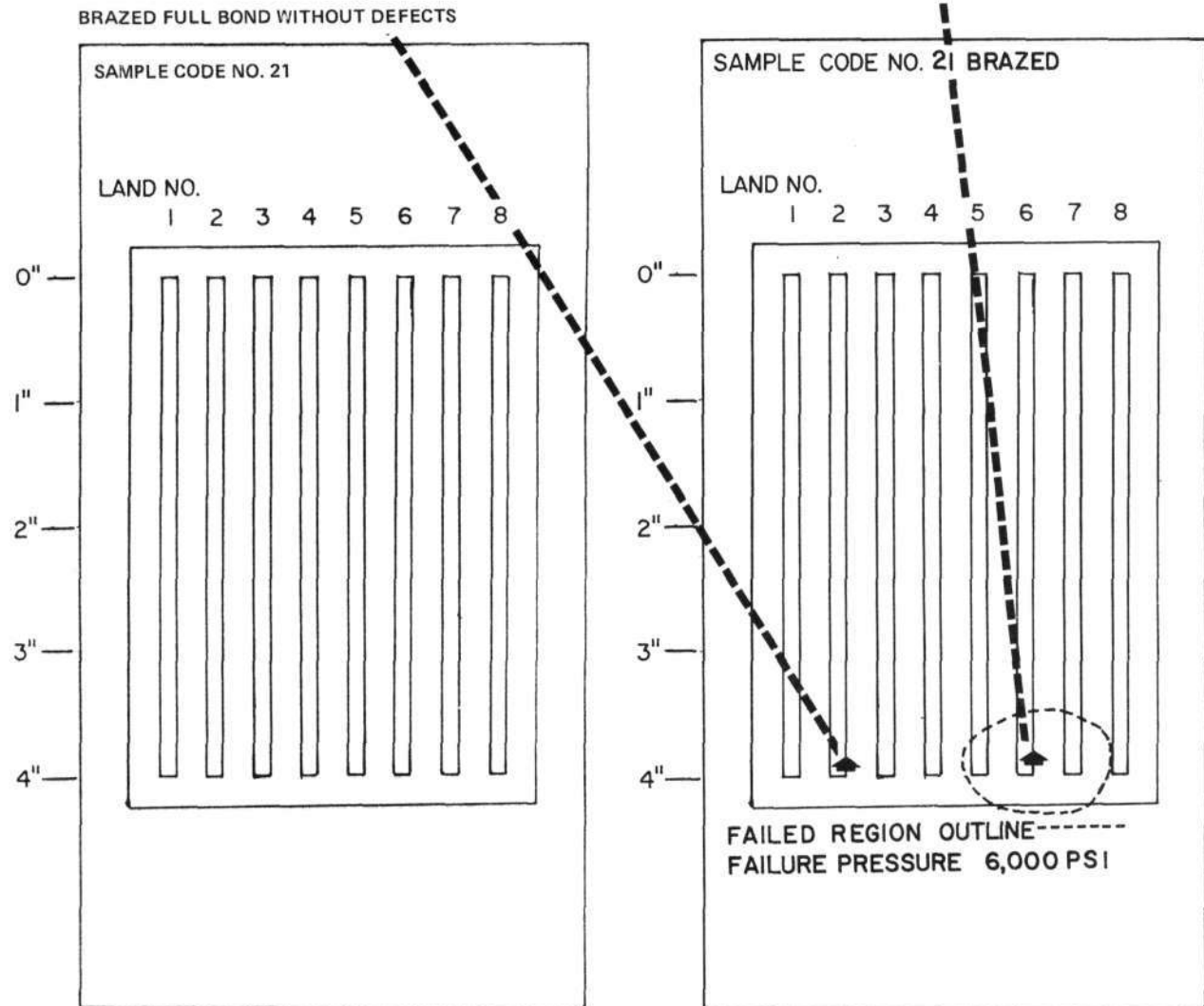
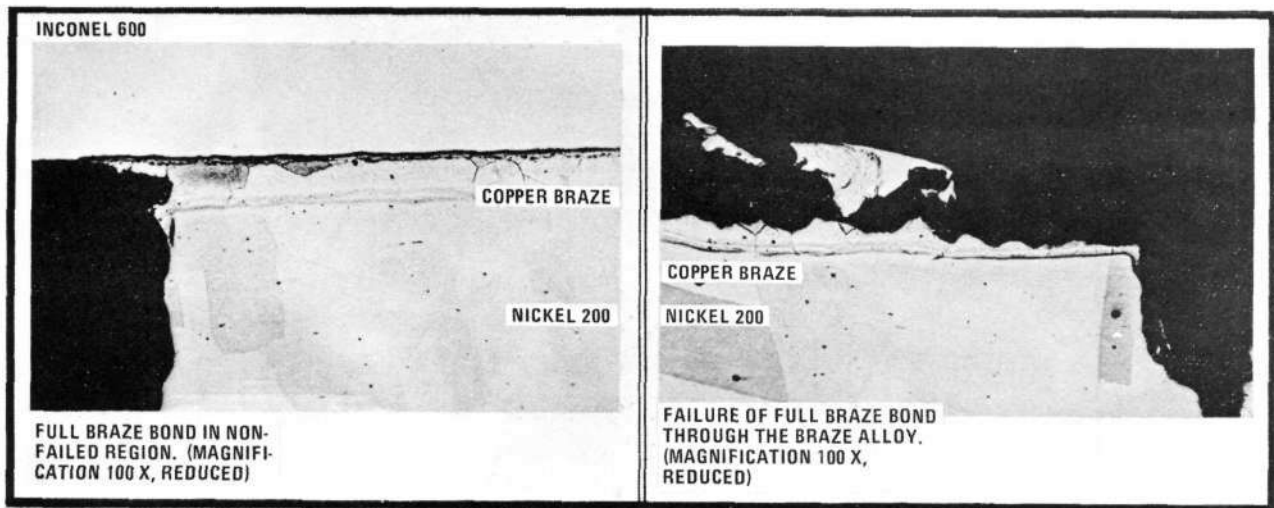
HNDT



TEST PRESSURE 1380 PSI

UT

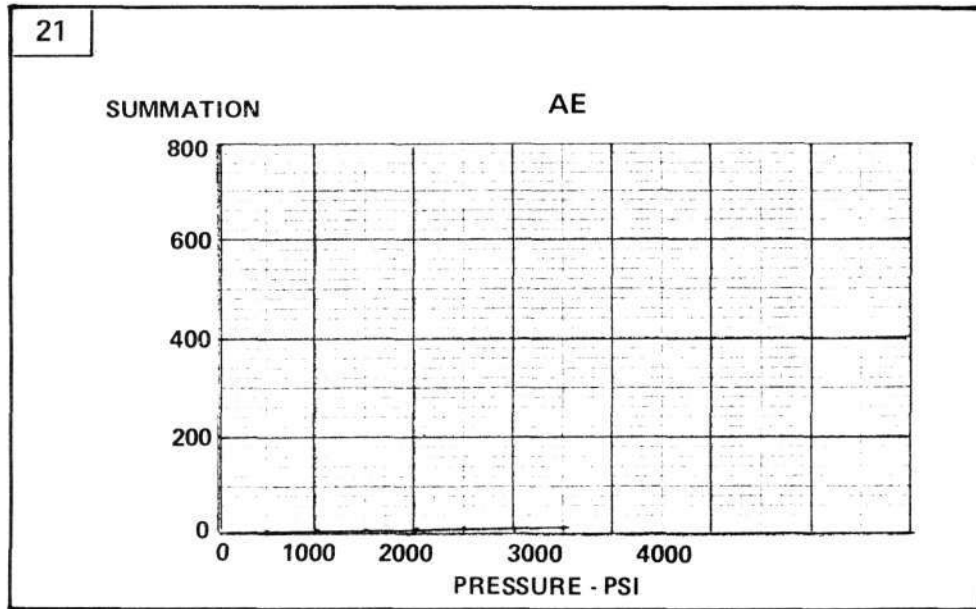




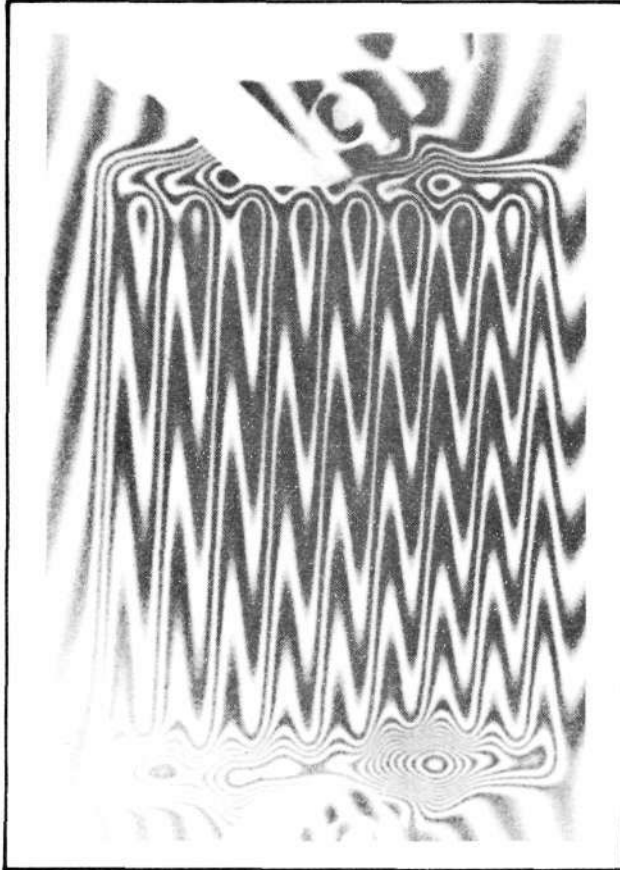
TEST RESULTS FOR BRAZED FULL BOND PANEL NO. 21

FIGURE A-18

BRAZE CONT'D

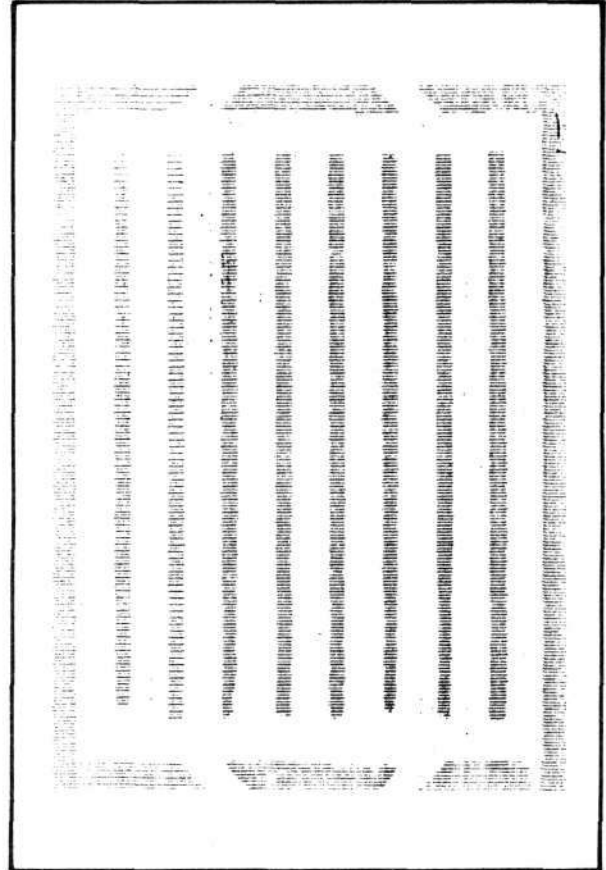


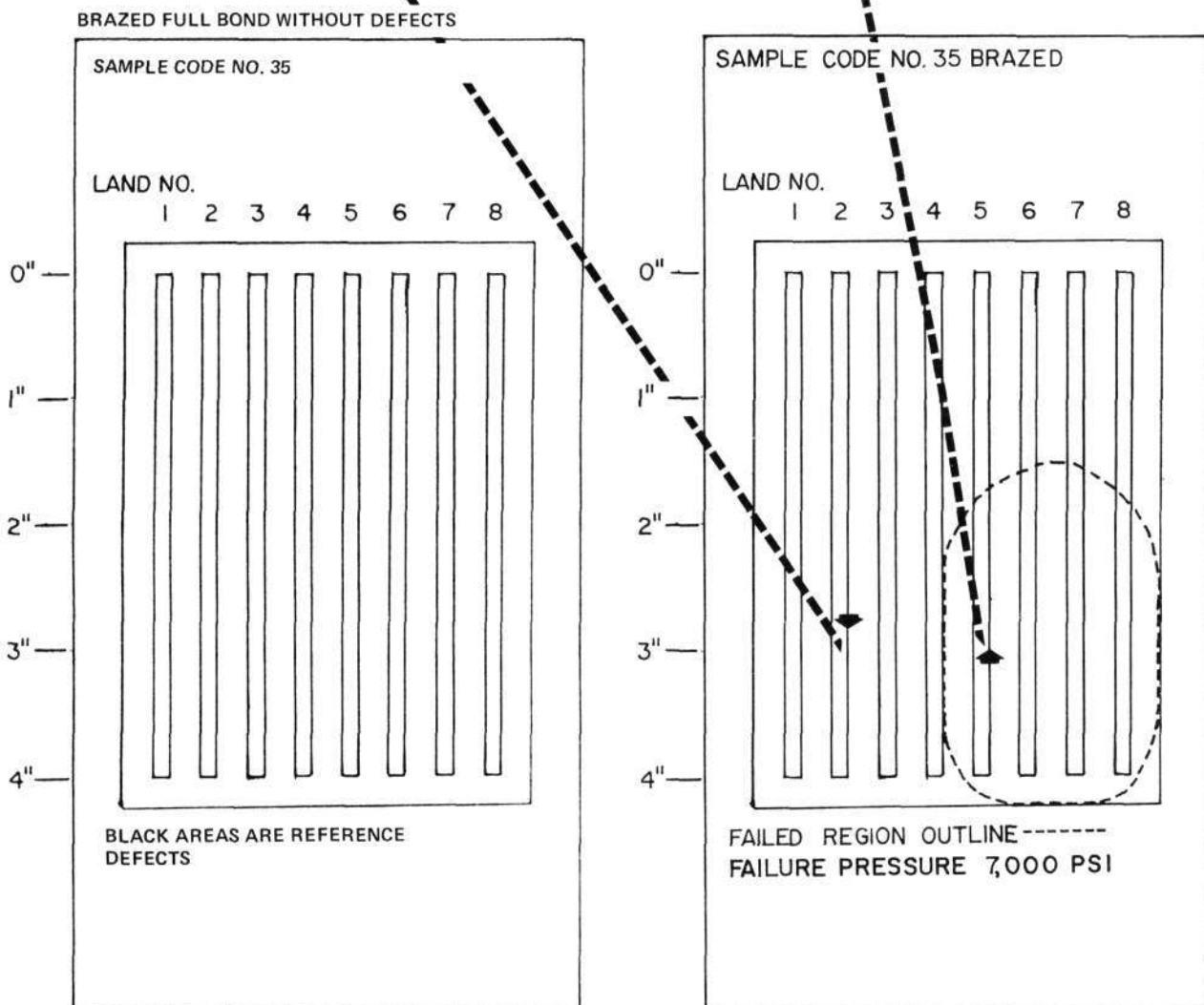
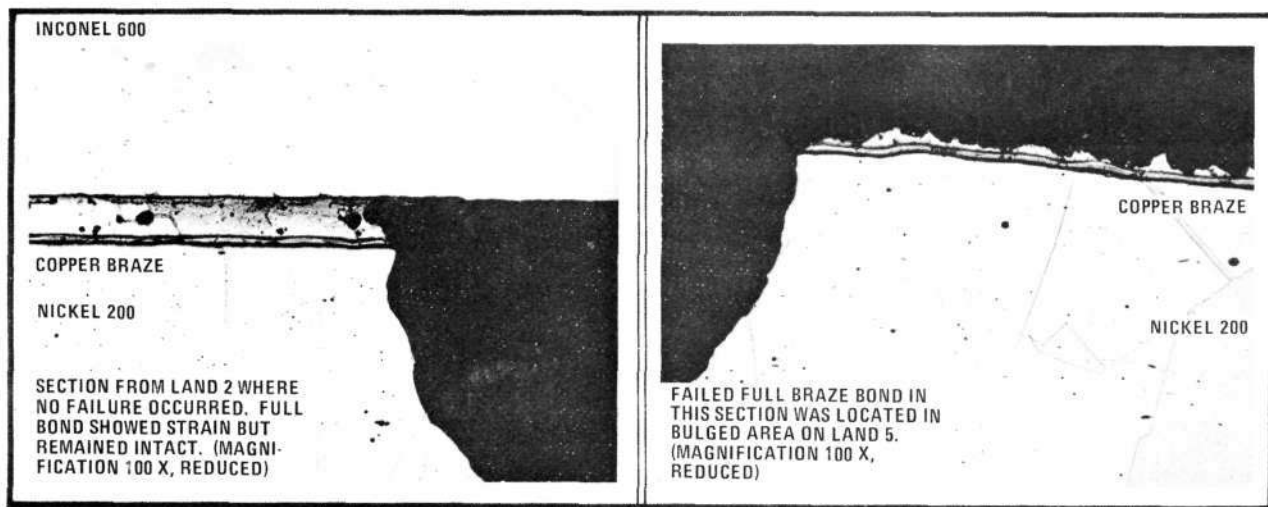
HNDT



TEST PRESSURE 1360 PSI

UT



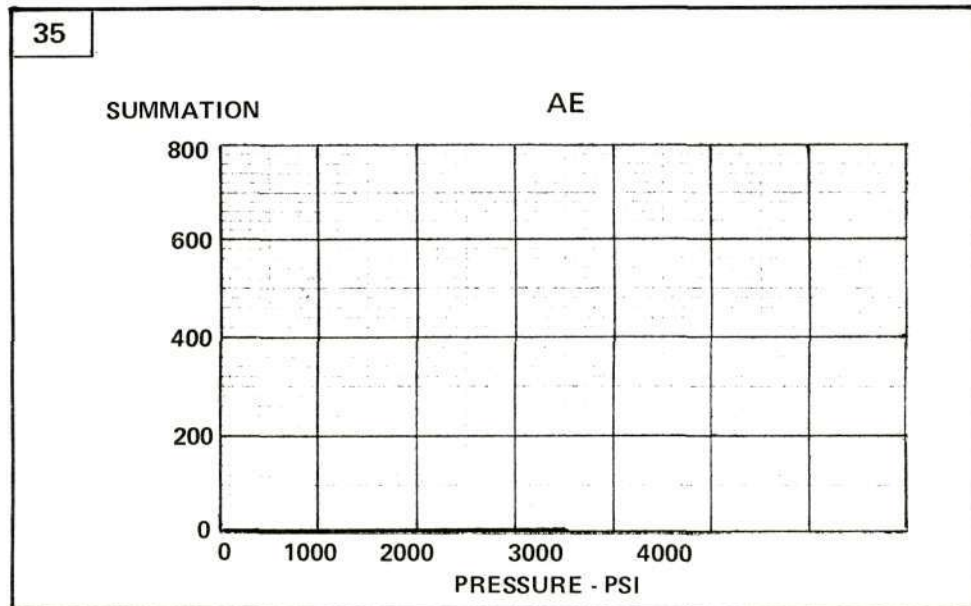


TEST RESULTS ON BRAZED FULL BOND PANEL NO. 35

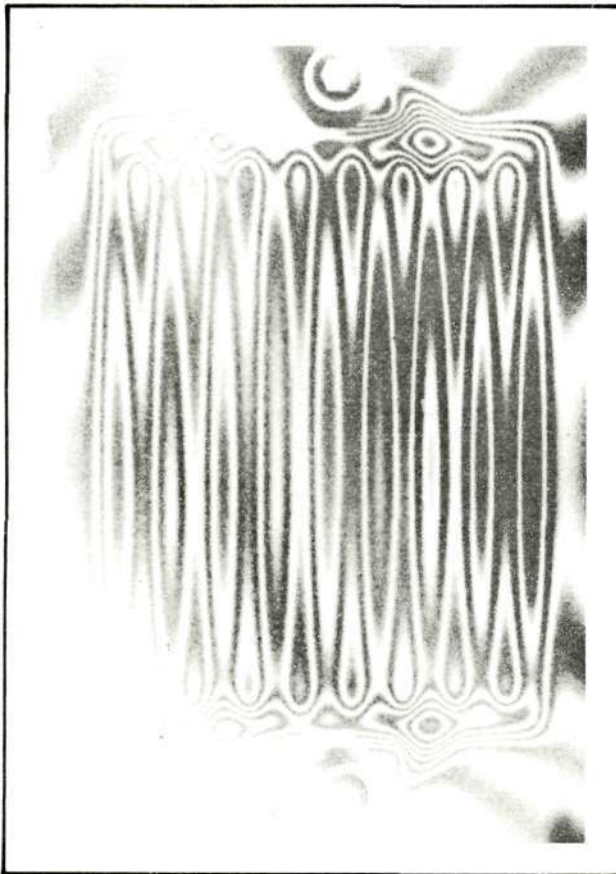
FIGURE A-19



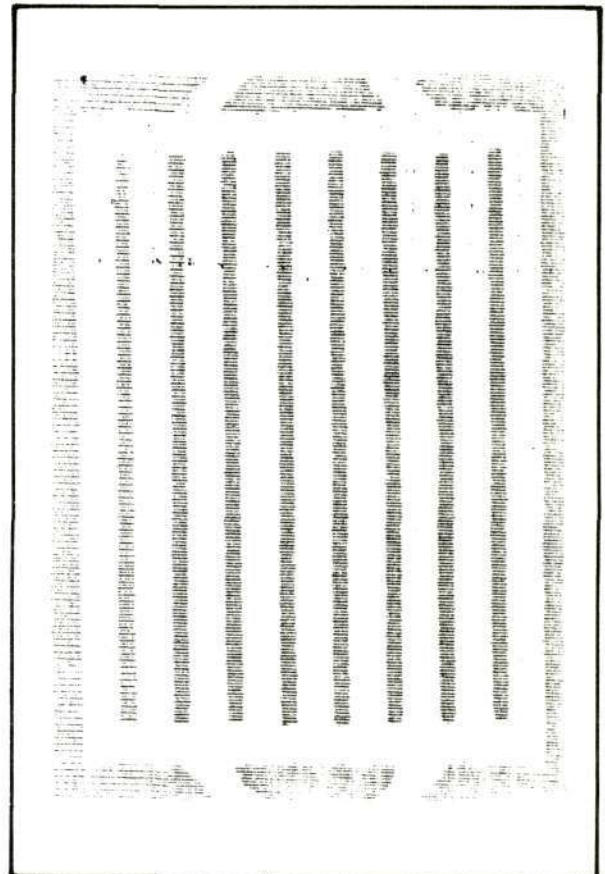
# BRAZE CONT'D



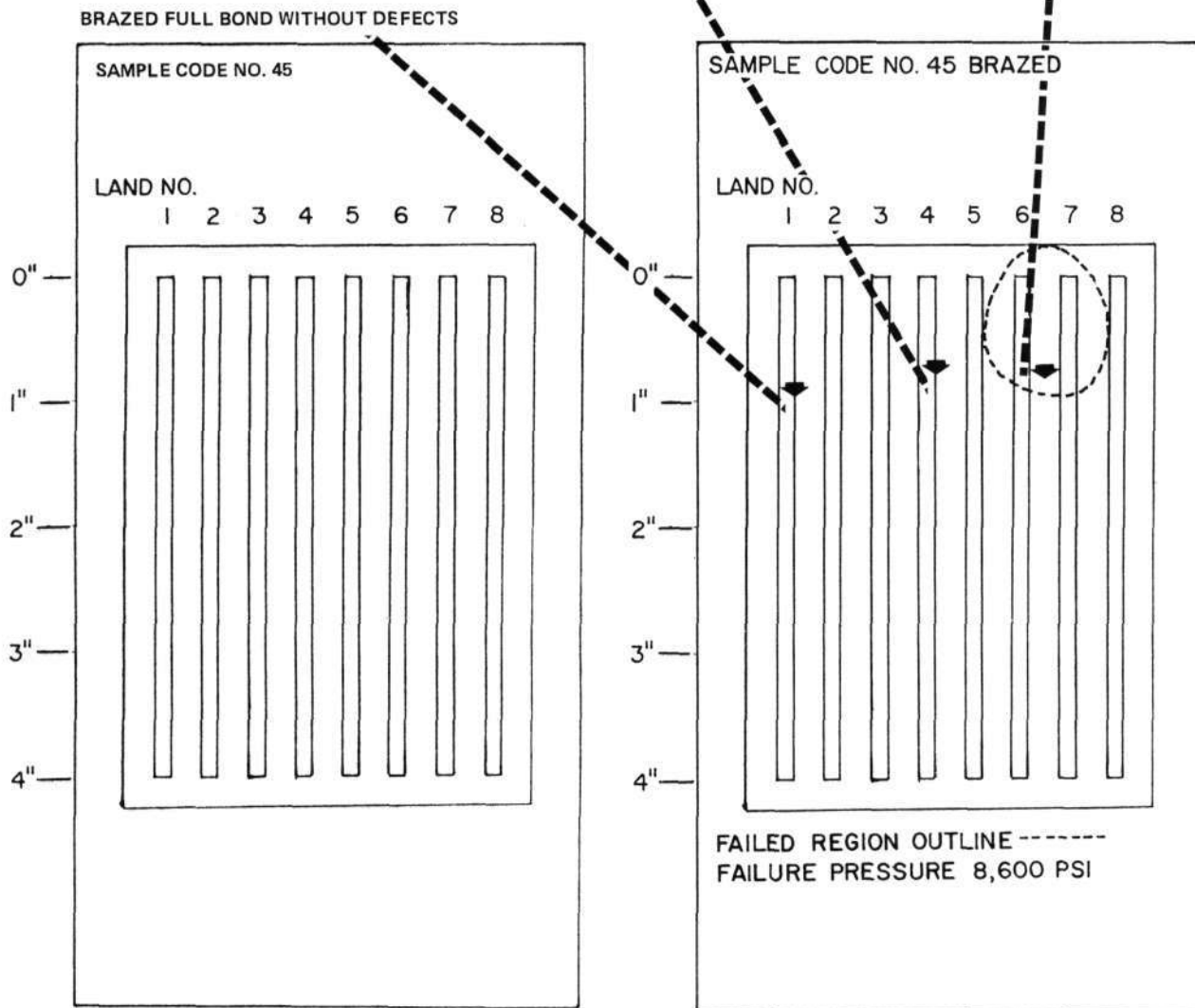
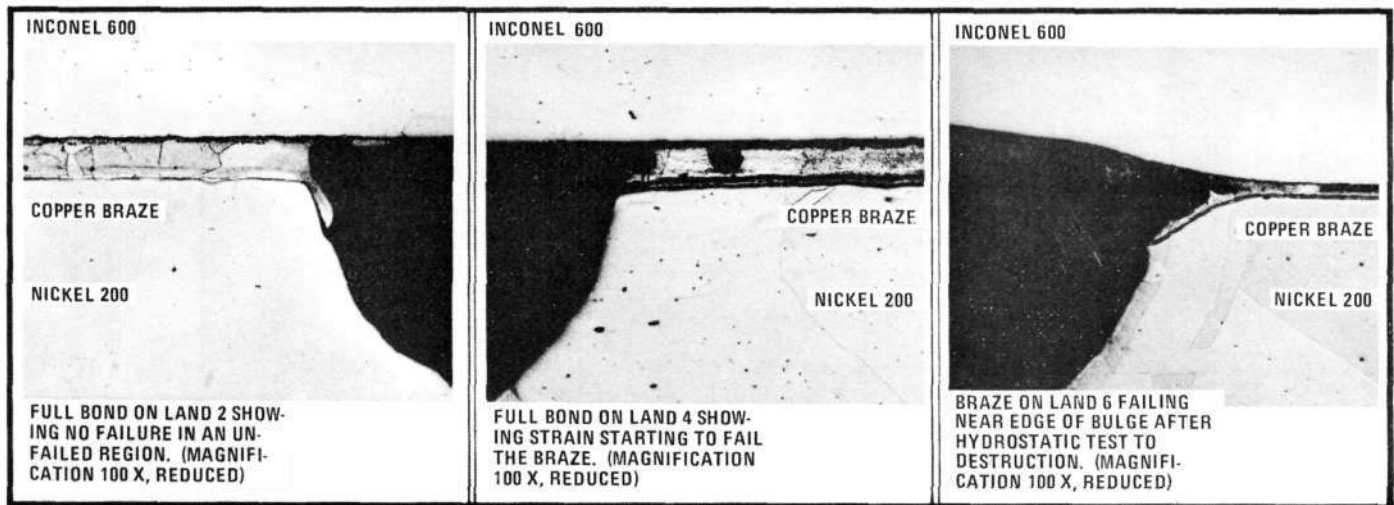
HNDT



UT



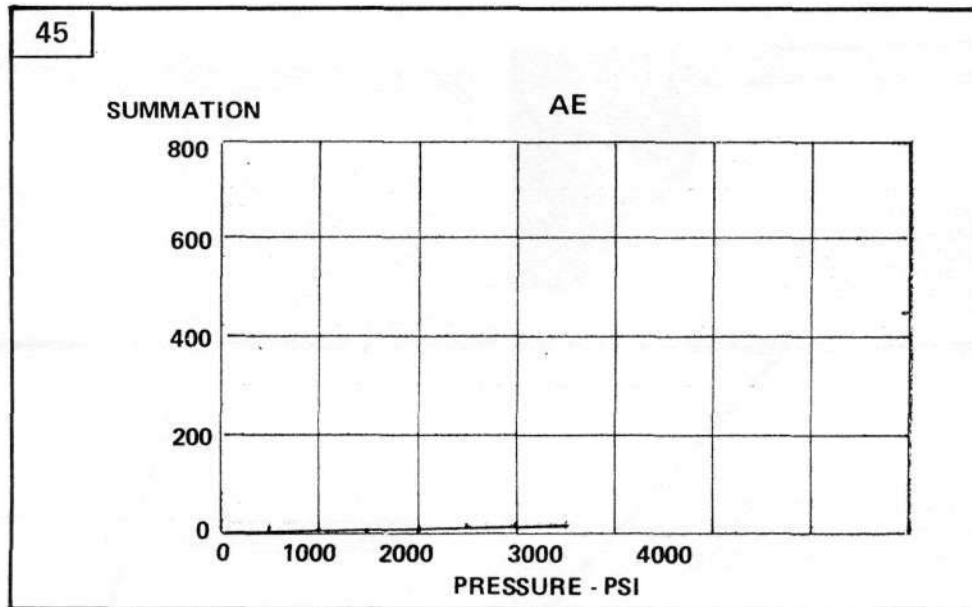
TEST PRESSURE 1460 PSI



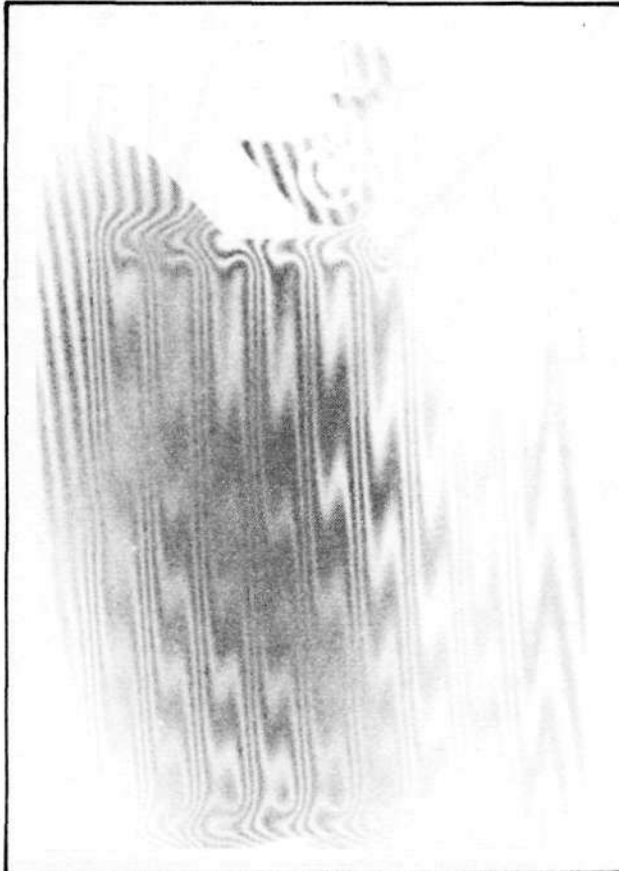
TEST RESULTS ON BRAZED FULL BOND PANEL NO. 45

FIGURE A-20

# BRAZE CONT'D

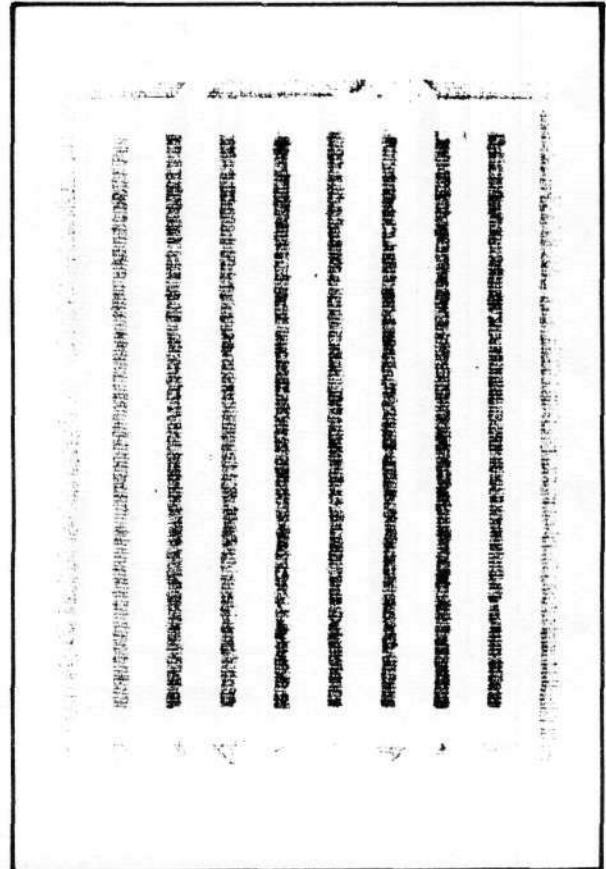


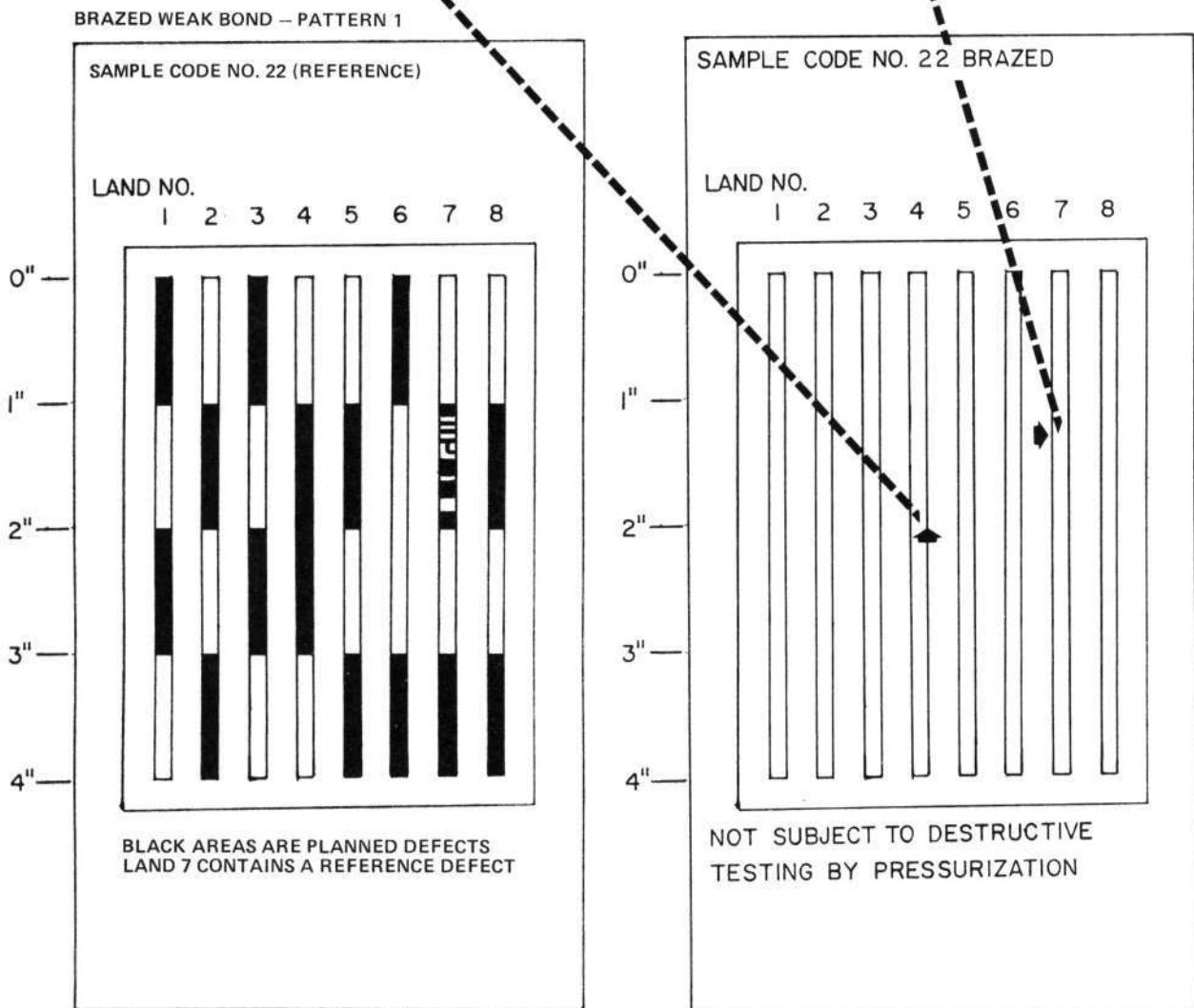
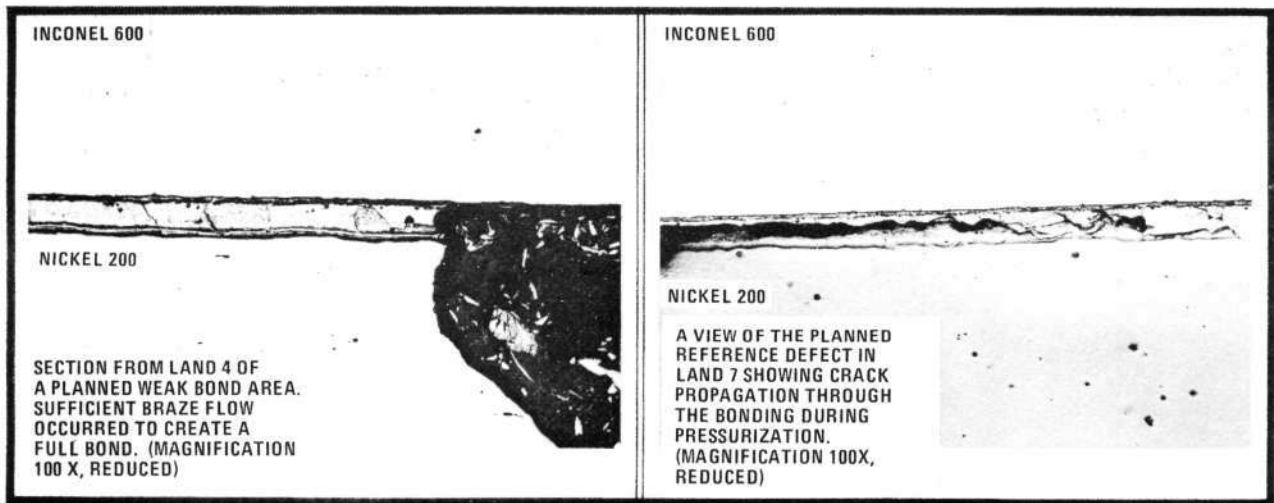
HNDT



TEST PRESSURE 1400 PSI

UT





TEST RESULTS ON BRAZED WEAK BOND PANEL NO. 22

FIGURE A-21



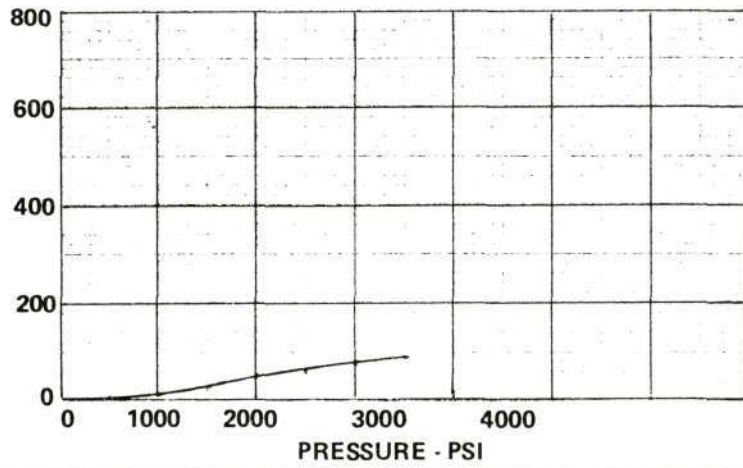
BRAZE CONT'D

Reproduced from  
best available copy.

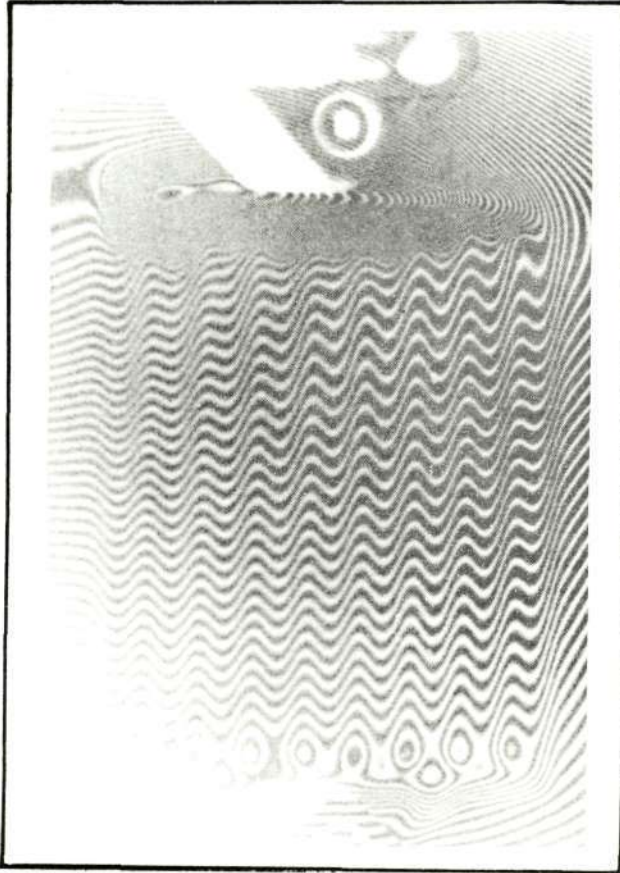
22

SUMMATION

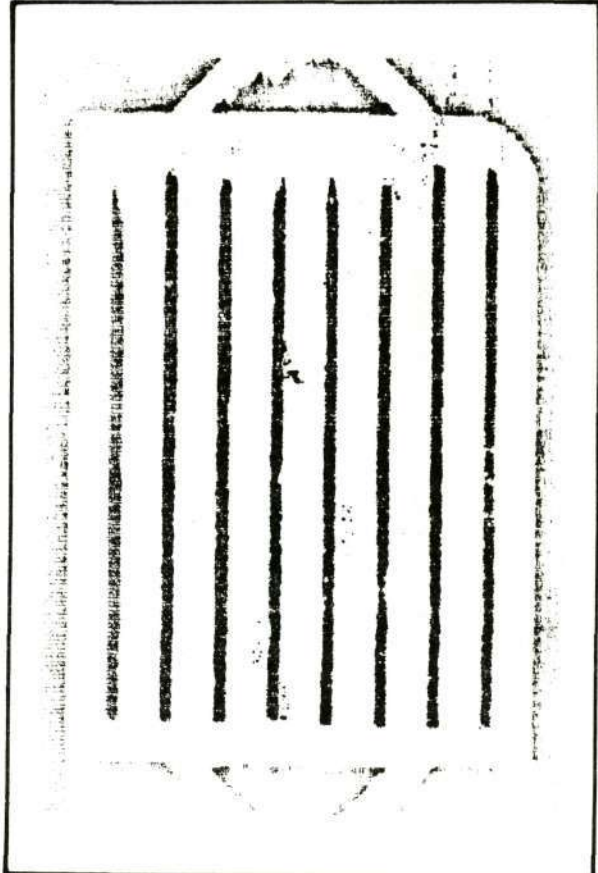
AE



HNDT

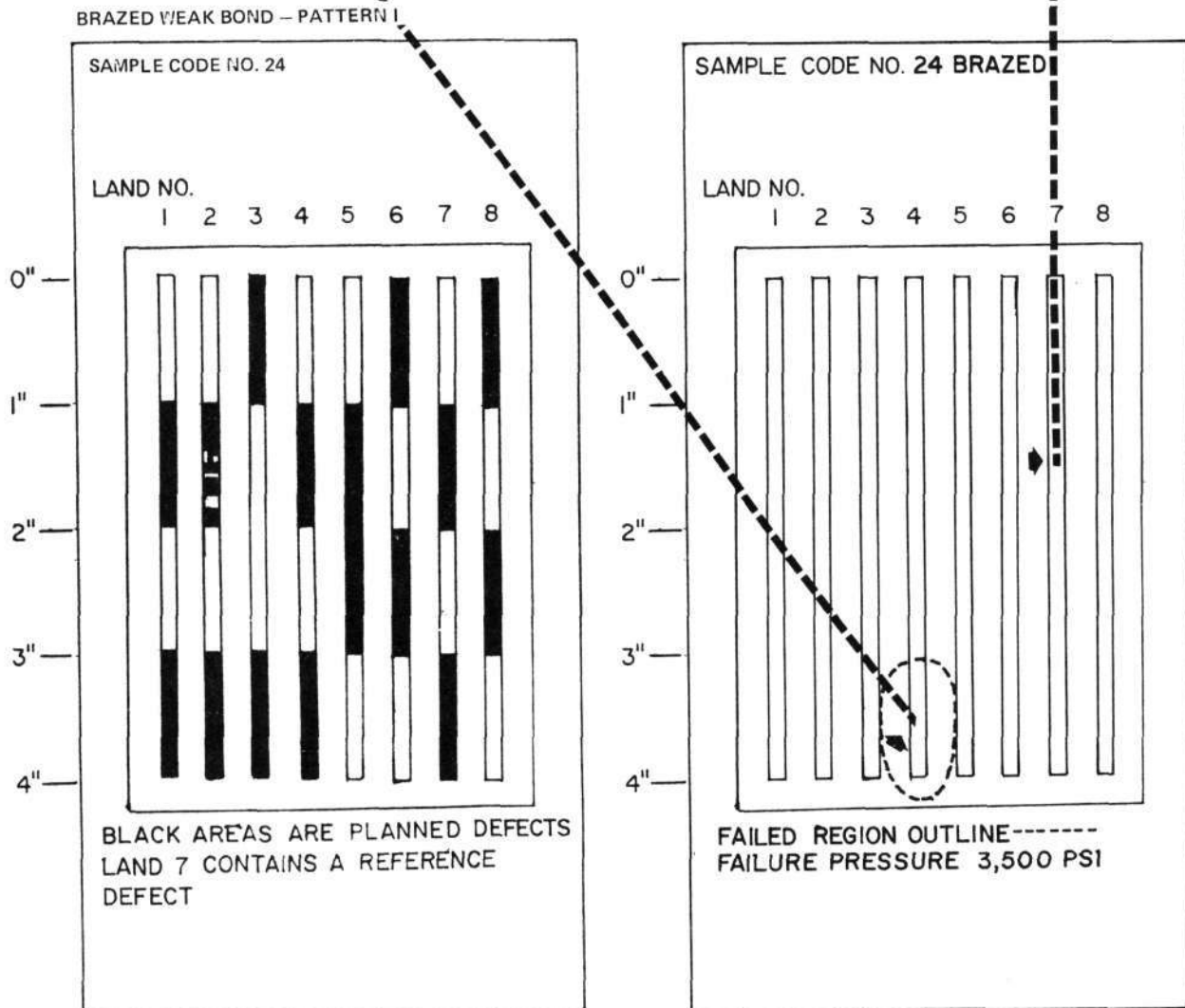
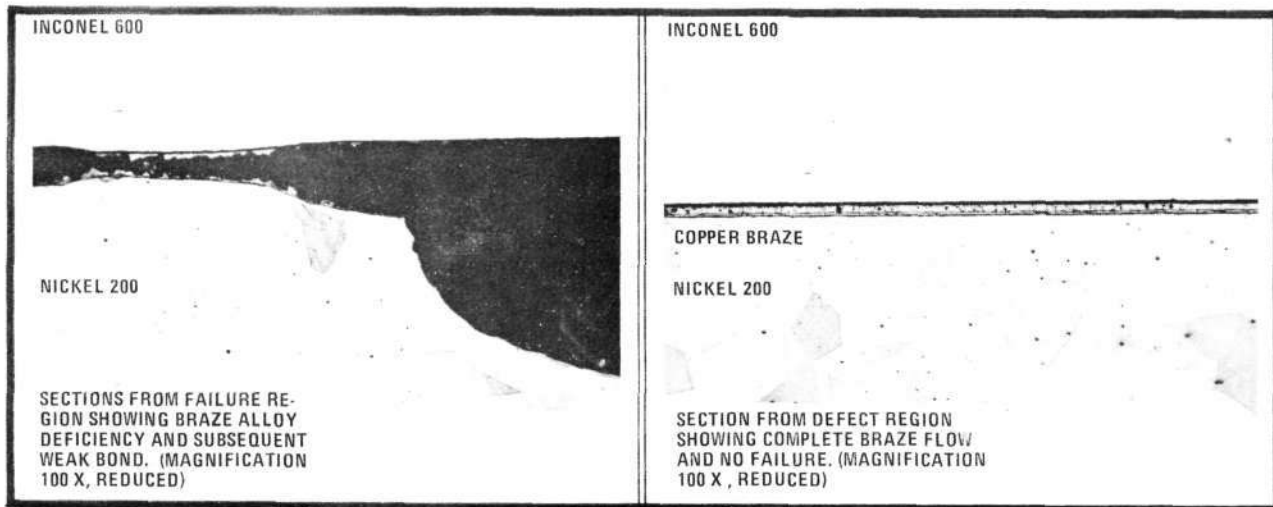


UT



TEST PRESSURE 1440 PSI

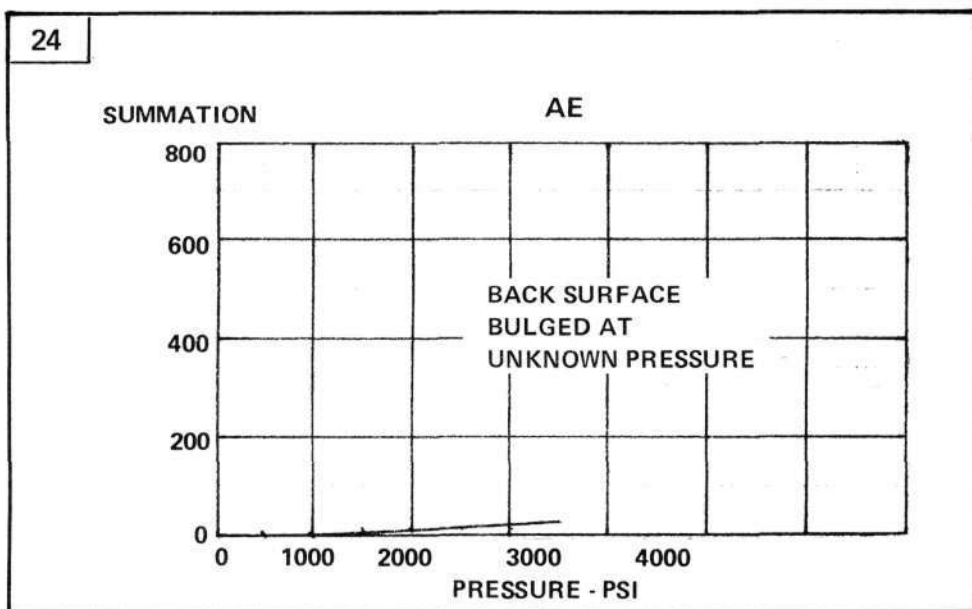




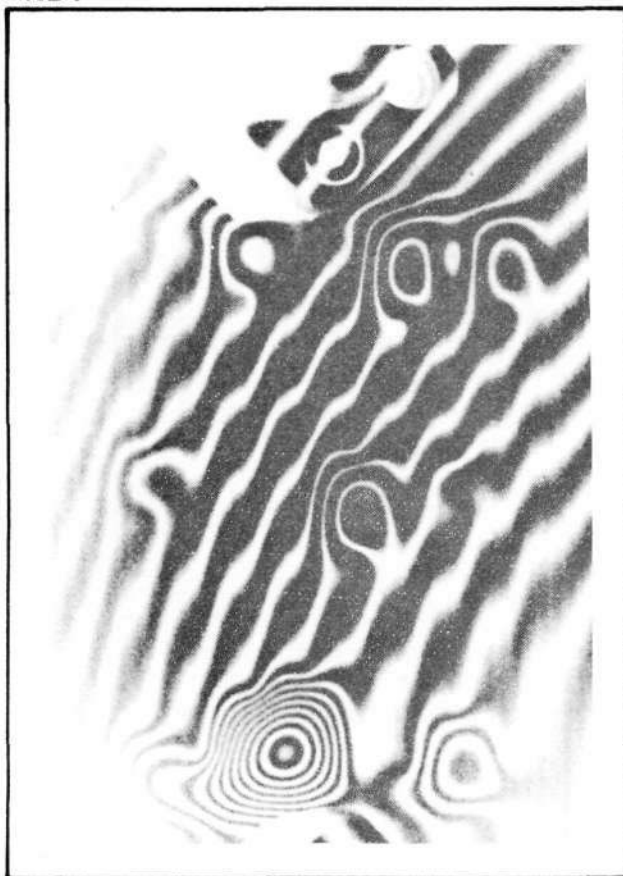
TEST RESULTS FOR BRAZED WEAK BOND PANEL NO. 24

FIGURE A-22

# BRAZE CONT'D

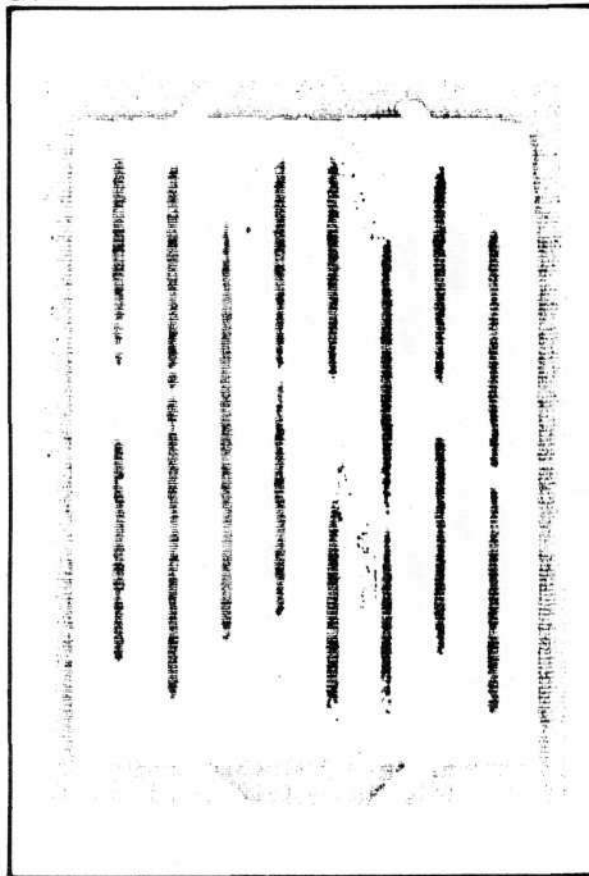


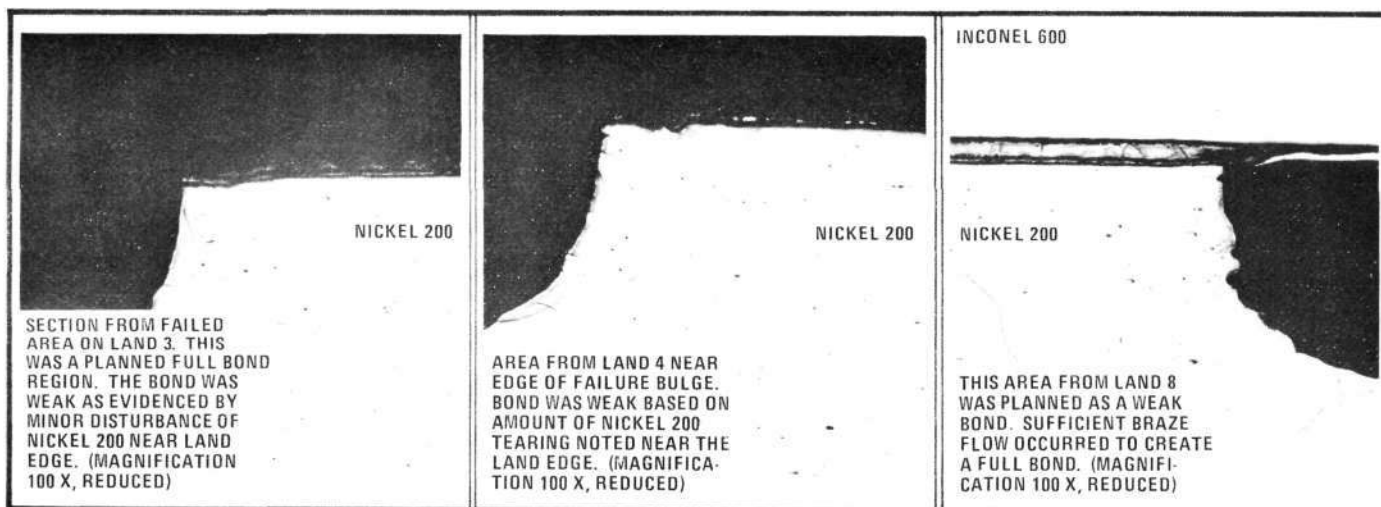
HNDT



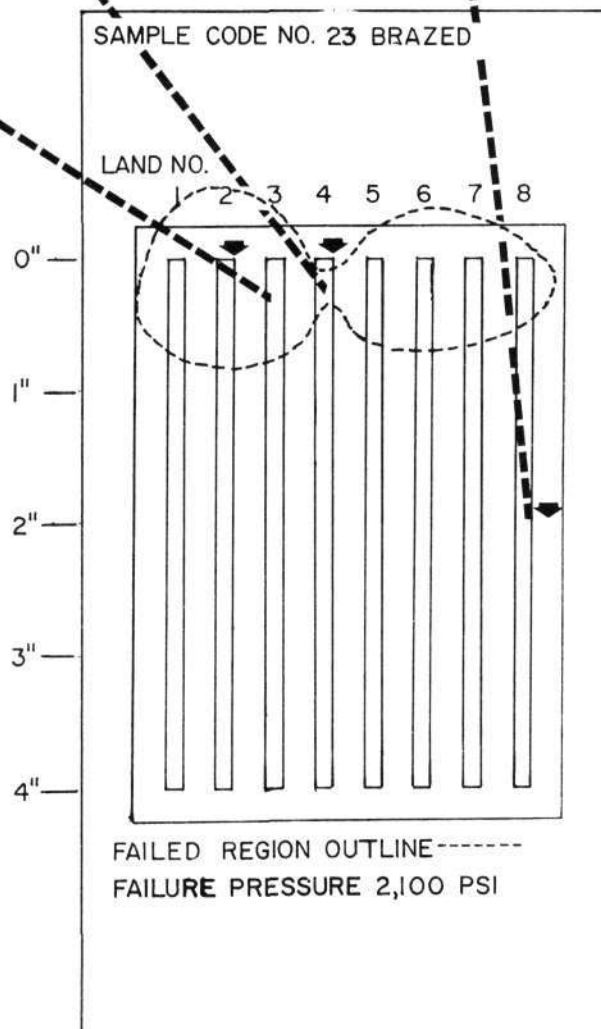
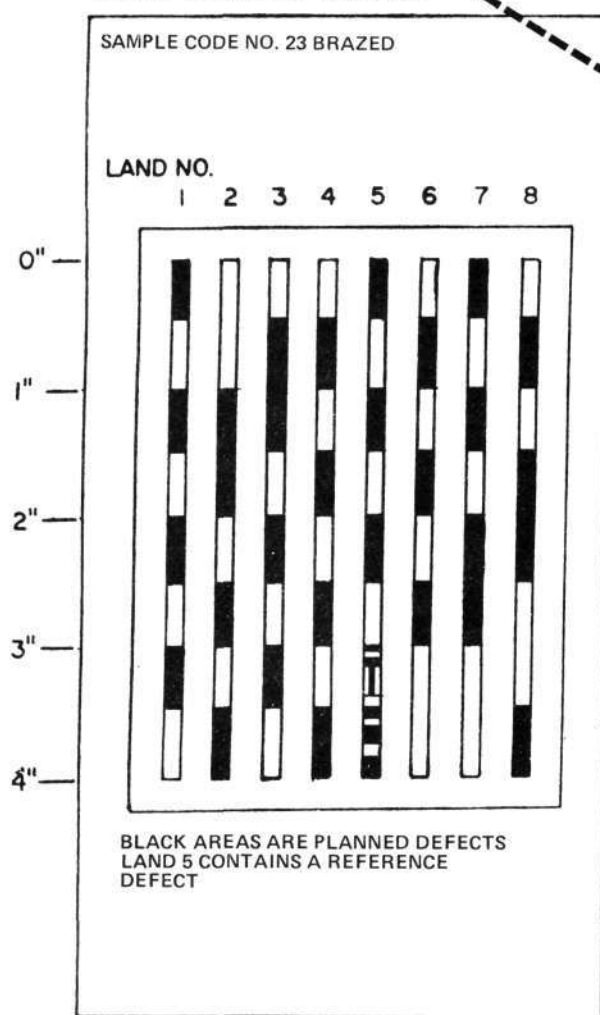
TEST PRESSURE 200 PSI

UT





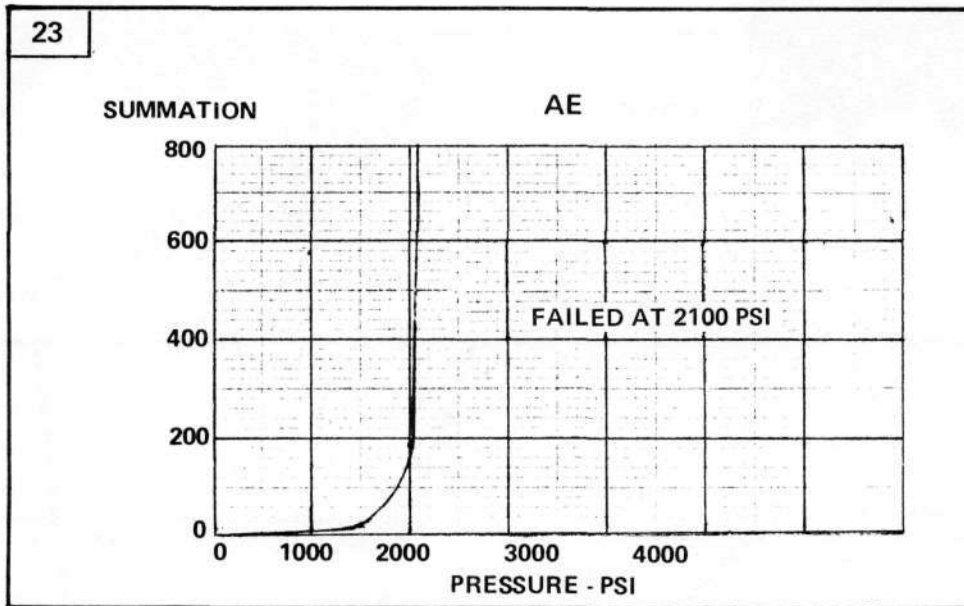
BRAZED WEAK BOND—PATTERN 2



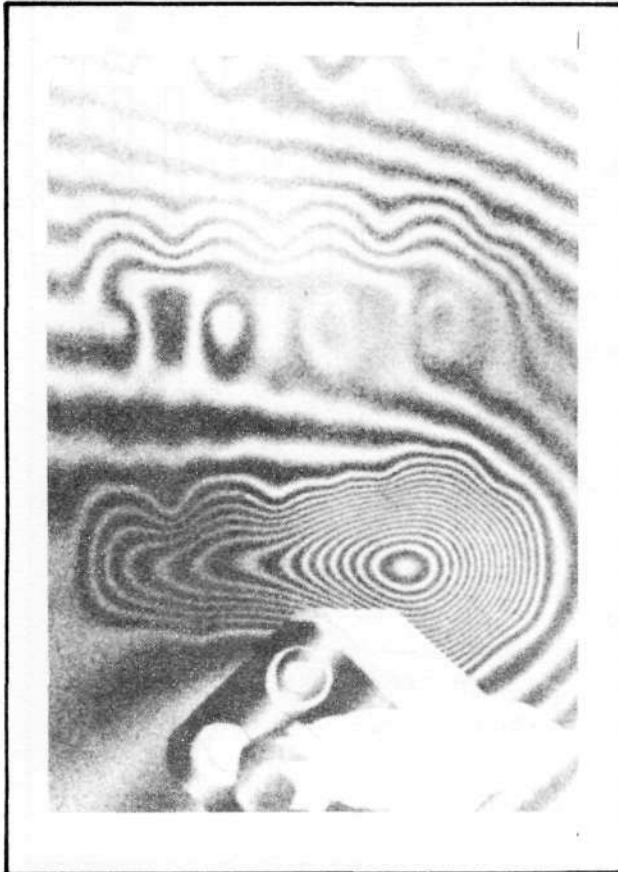
TEST RESULTS ON BRAZED WEAK BOND PANEL NO. 23

FIGURE A-23

BRAZE CONT'D

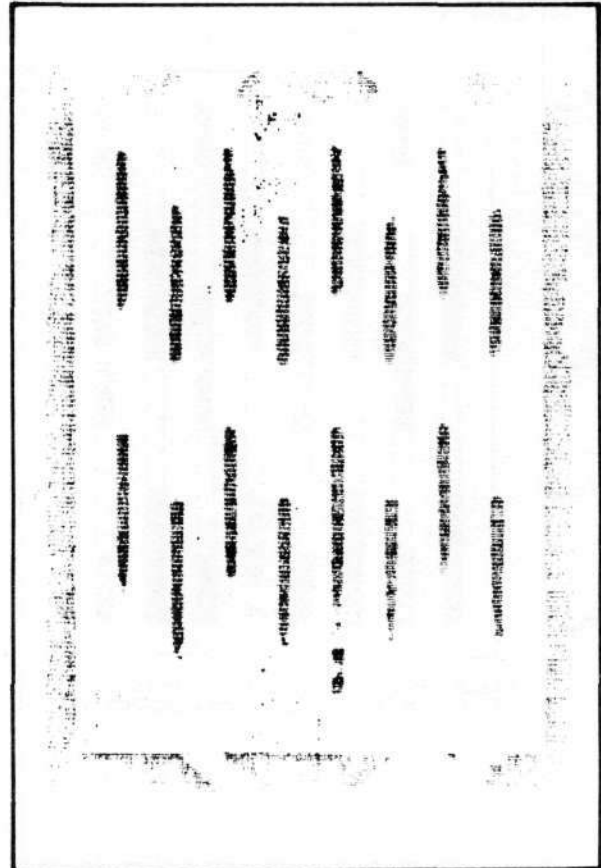


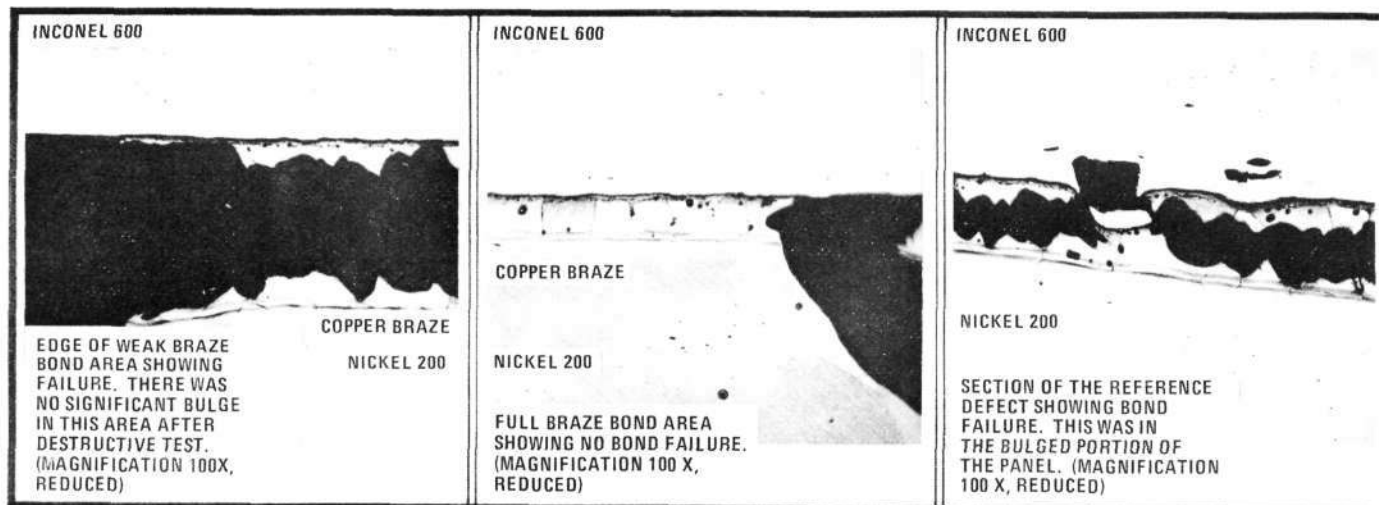
HNDT



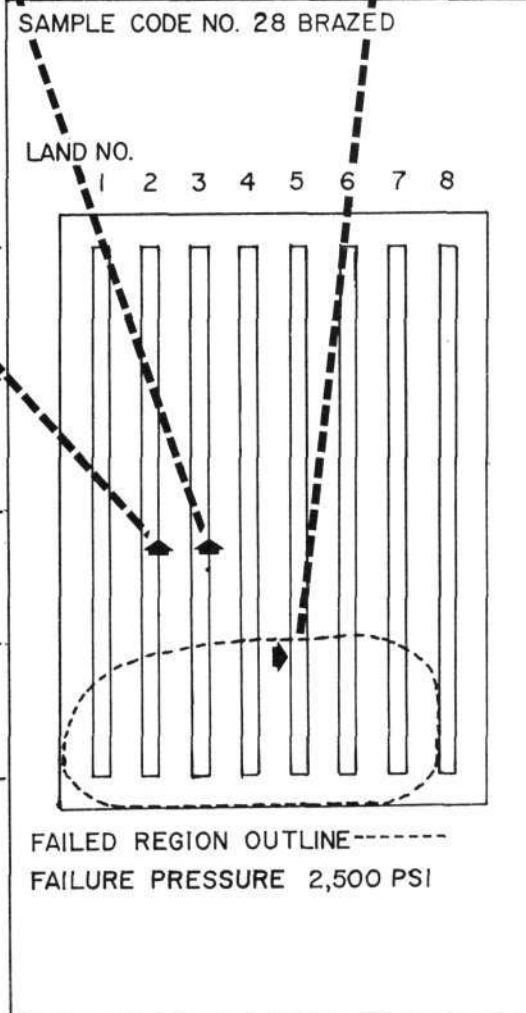
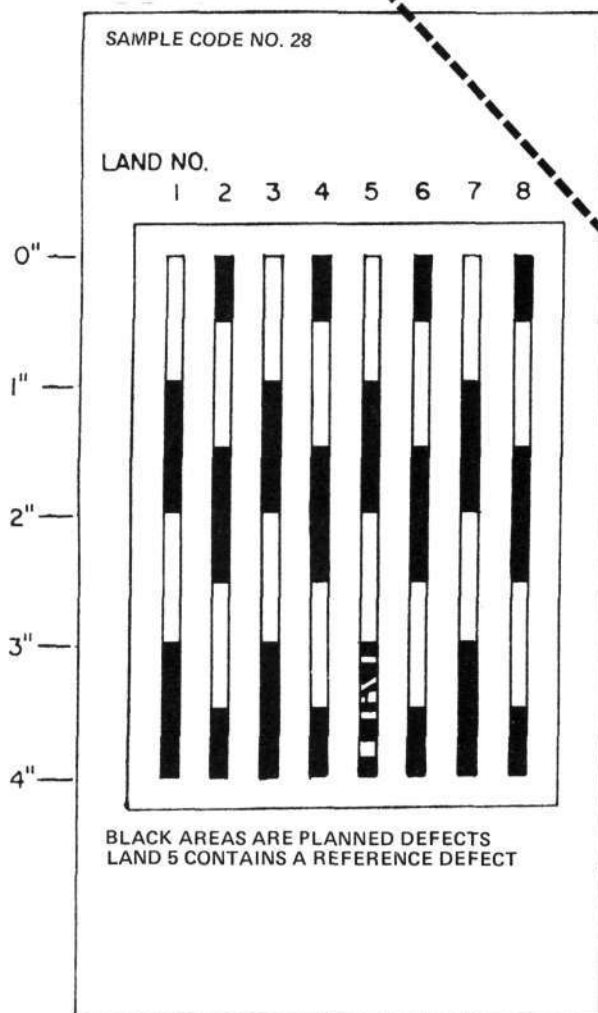
TEST PRESSURE 80 PSI

UT





# BRAZED WEAK BOND - PATTERN 2

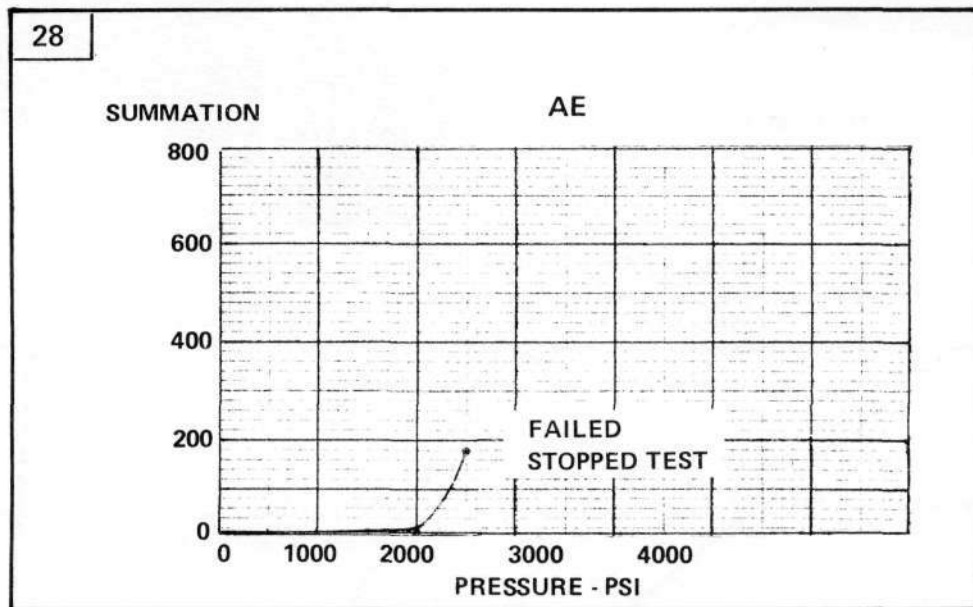


TEST RESULTS ON BRAZED WEAK BOND PANEL NO. 28

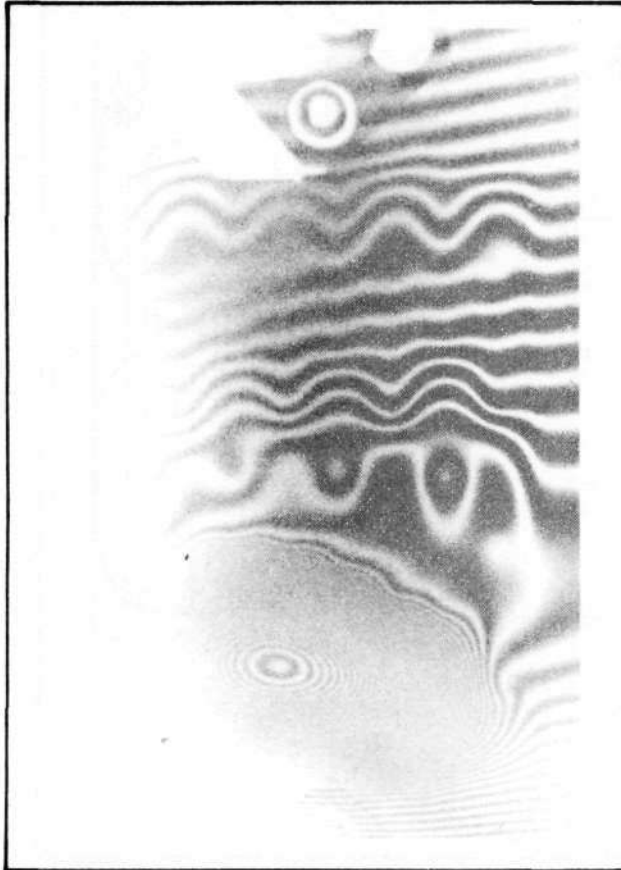
FIGURE A-24



BRAZE CONT'D

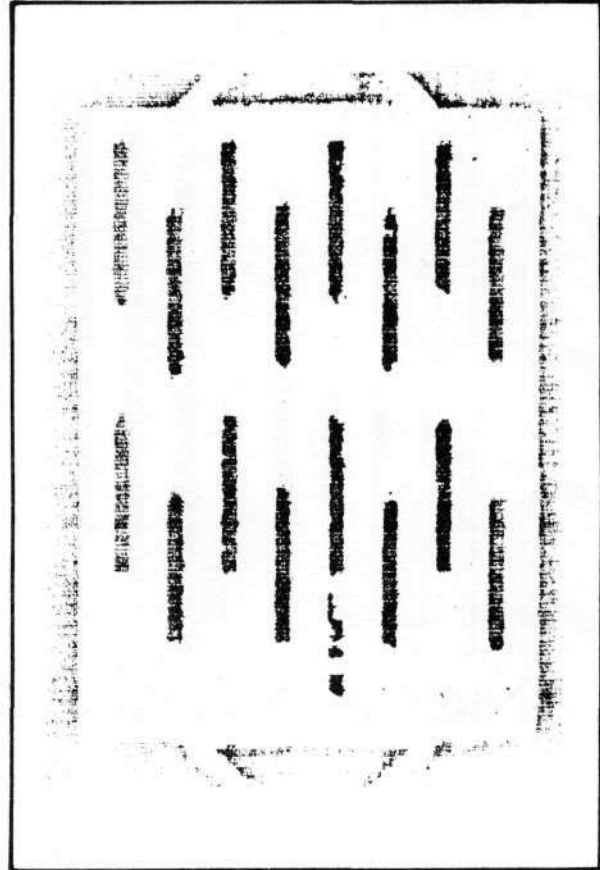


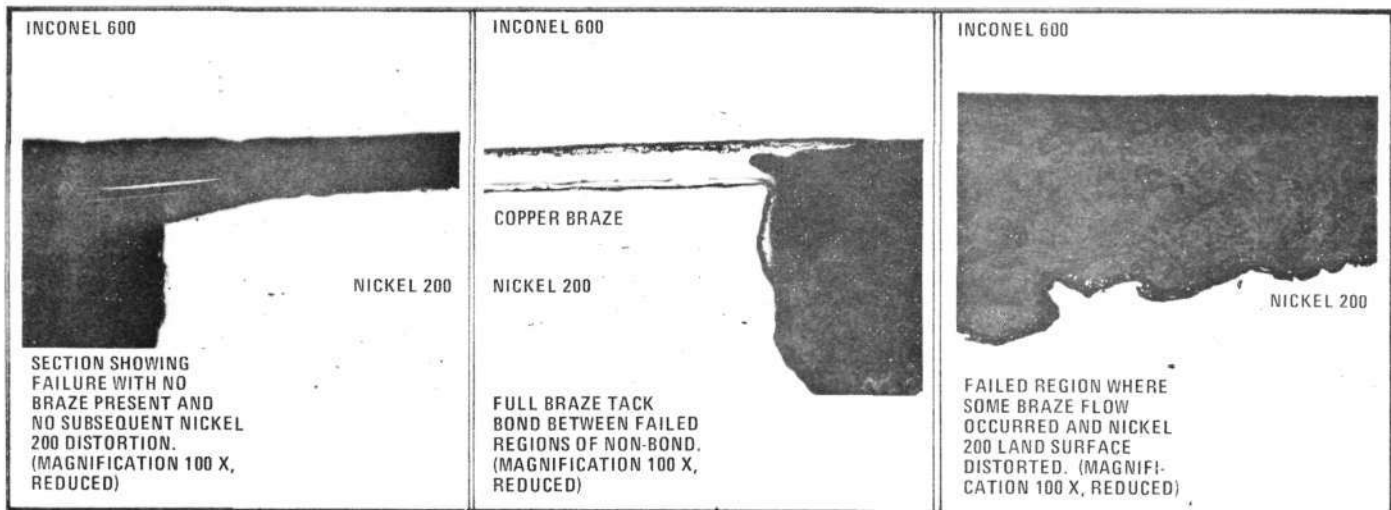
HNDT



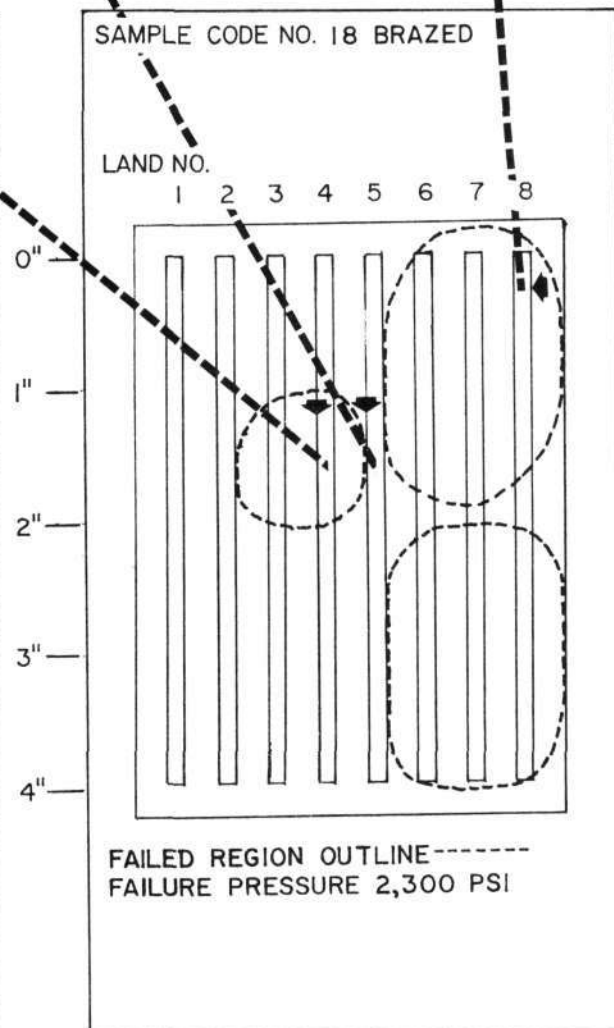
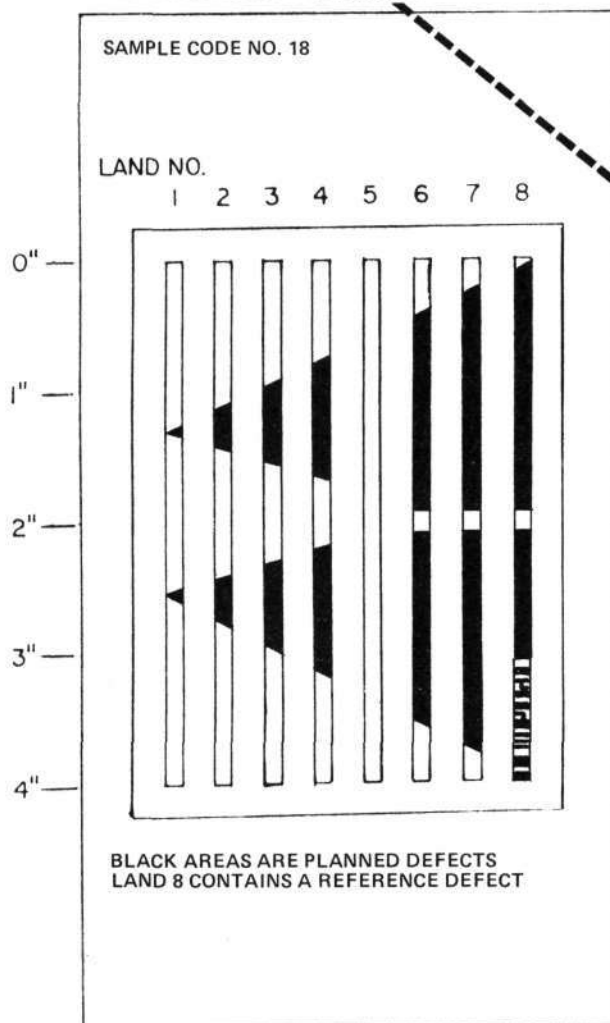
TEST PRESSURE 100 PSI

UT





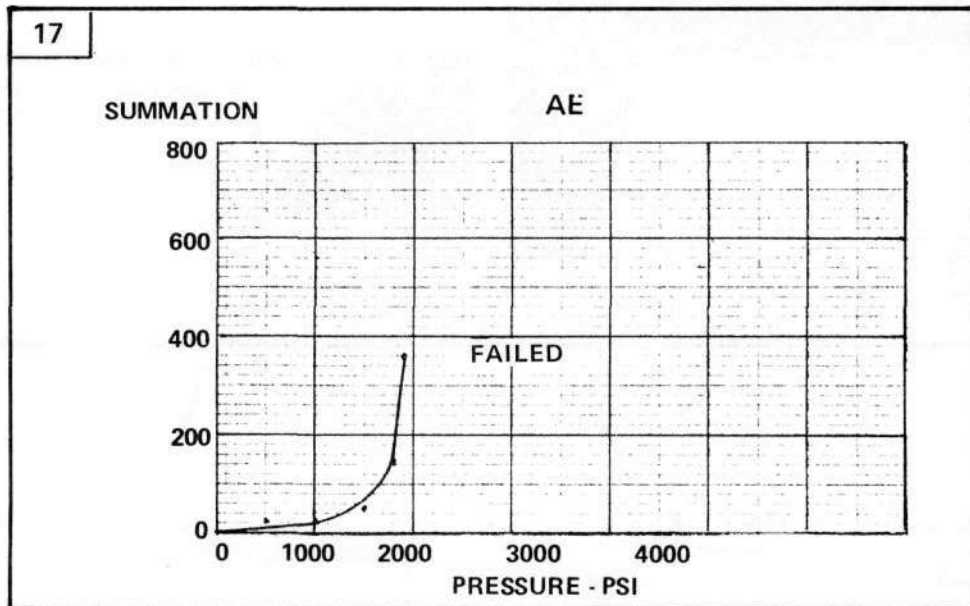
BRAZED WEAK BOND - PATTERN 3



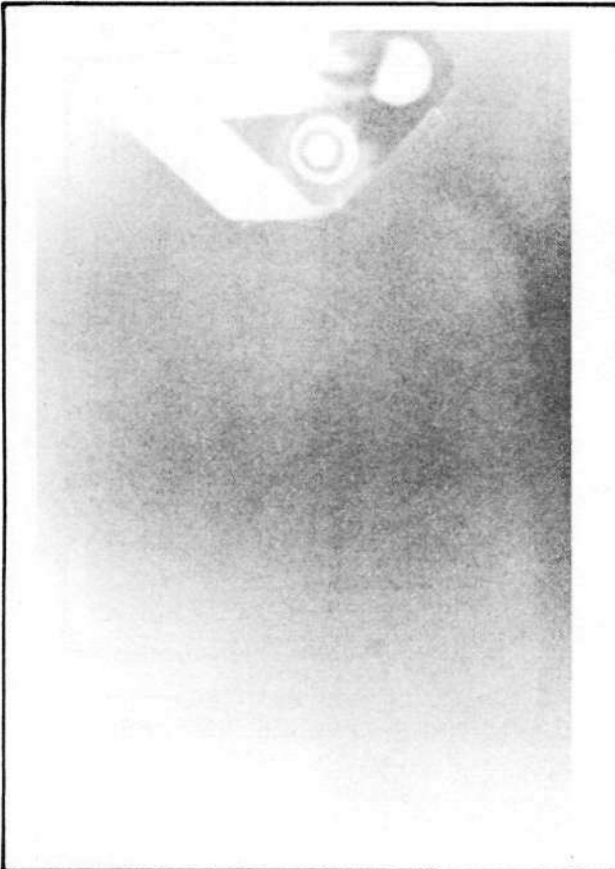
TEST RESULTS ON BRAZED WEAK BOND PANEL NO. 18

FIGURE A-25

# BRAZE NDE RESULTS

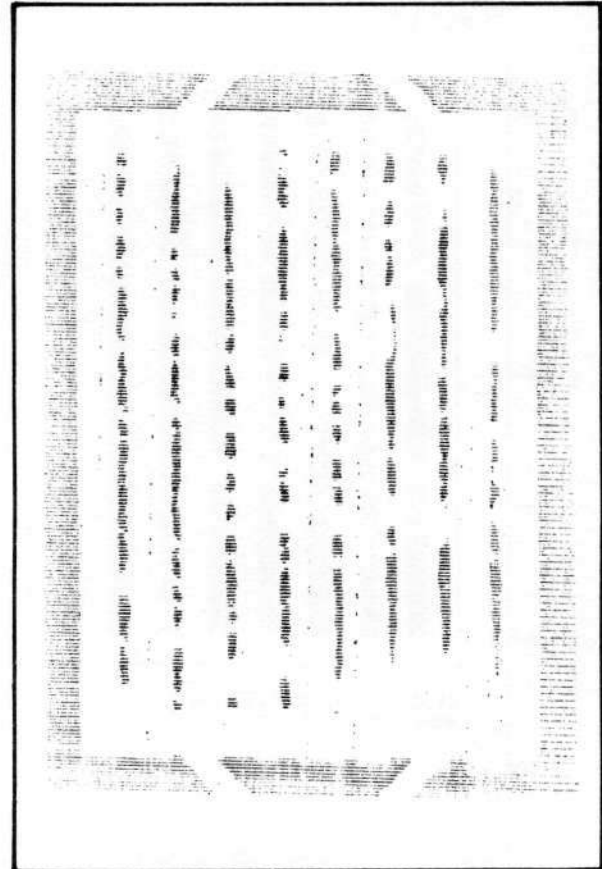


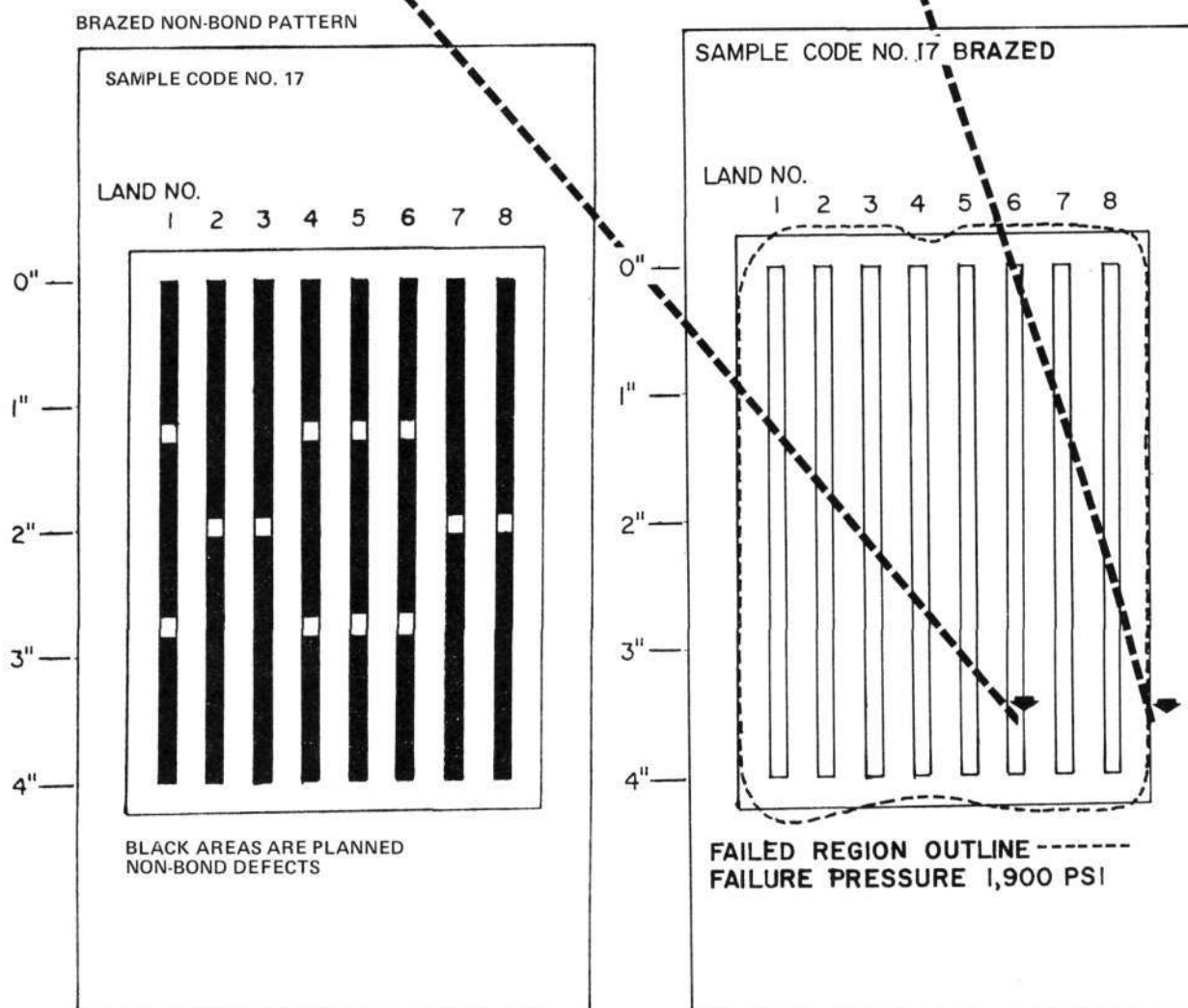
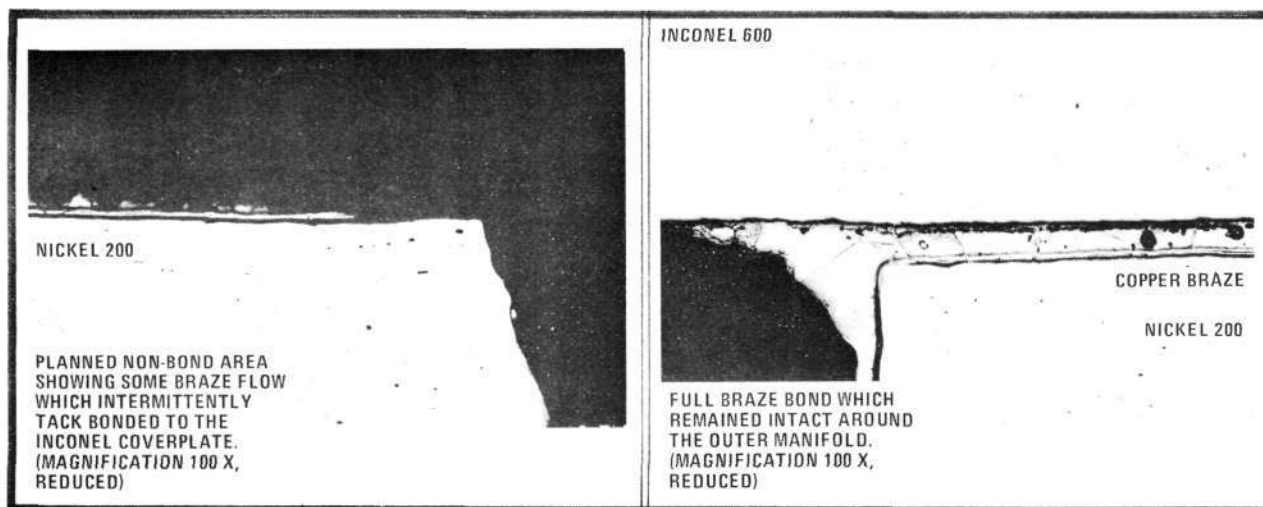
HNDT



TEST PRESSURE 1100 PSI

UT





TEST RESULTS ON BRAZED NON-BOND PANEL NO. 17

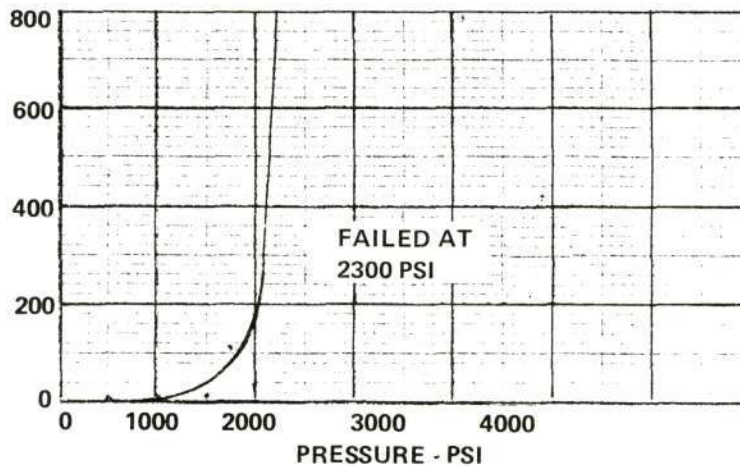
FIGURE A-26



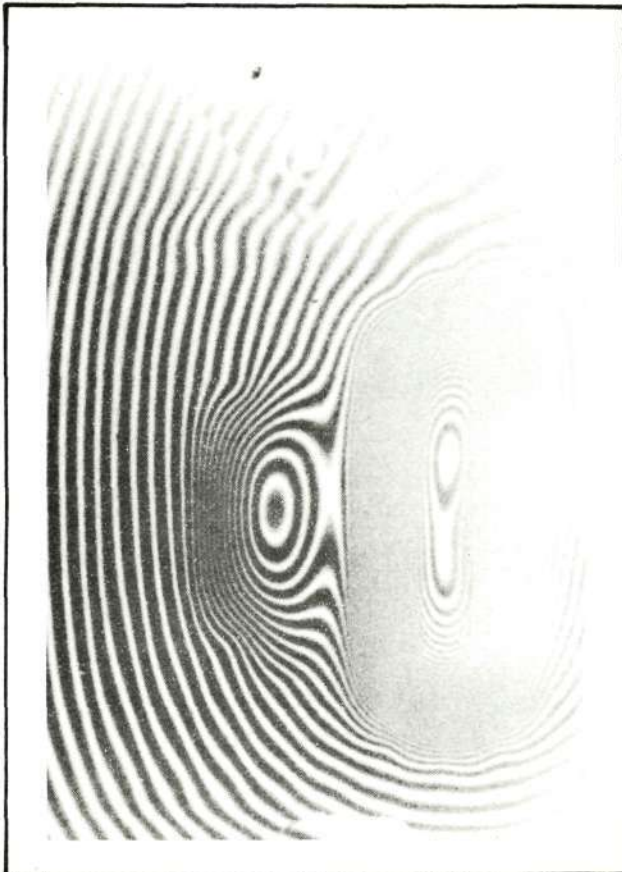
18

SUMMATION

AE

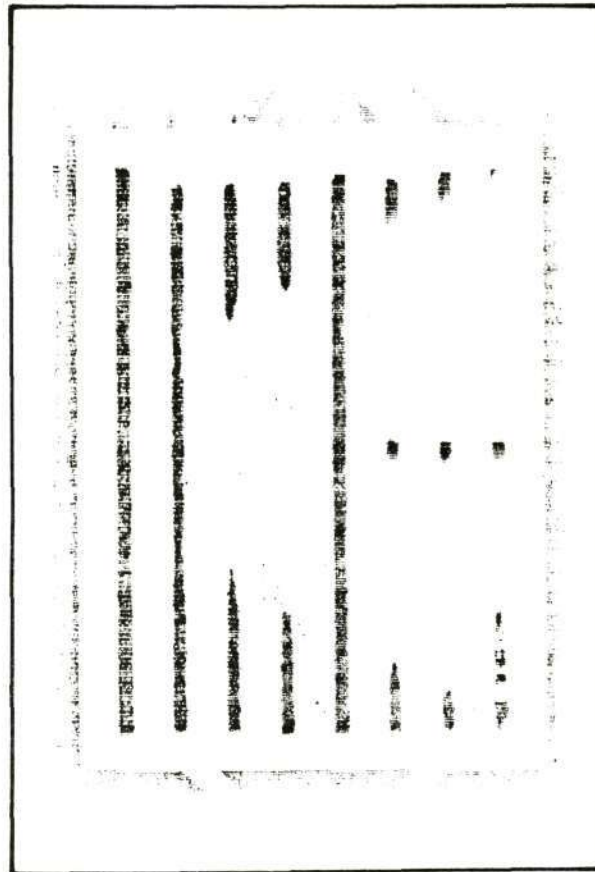


HNDT

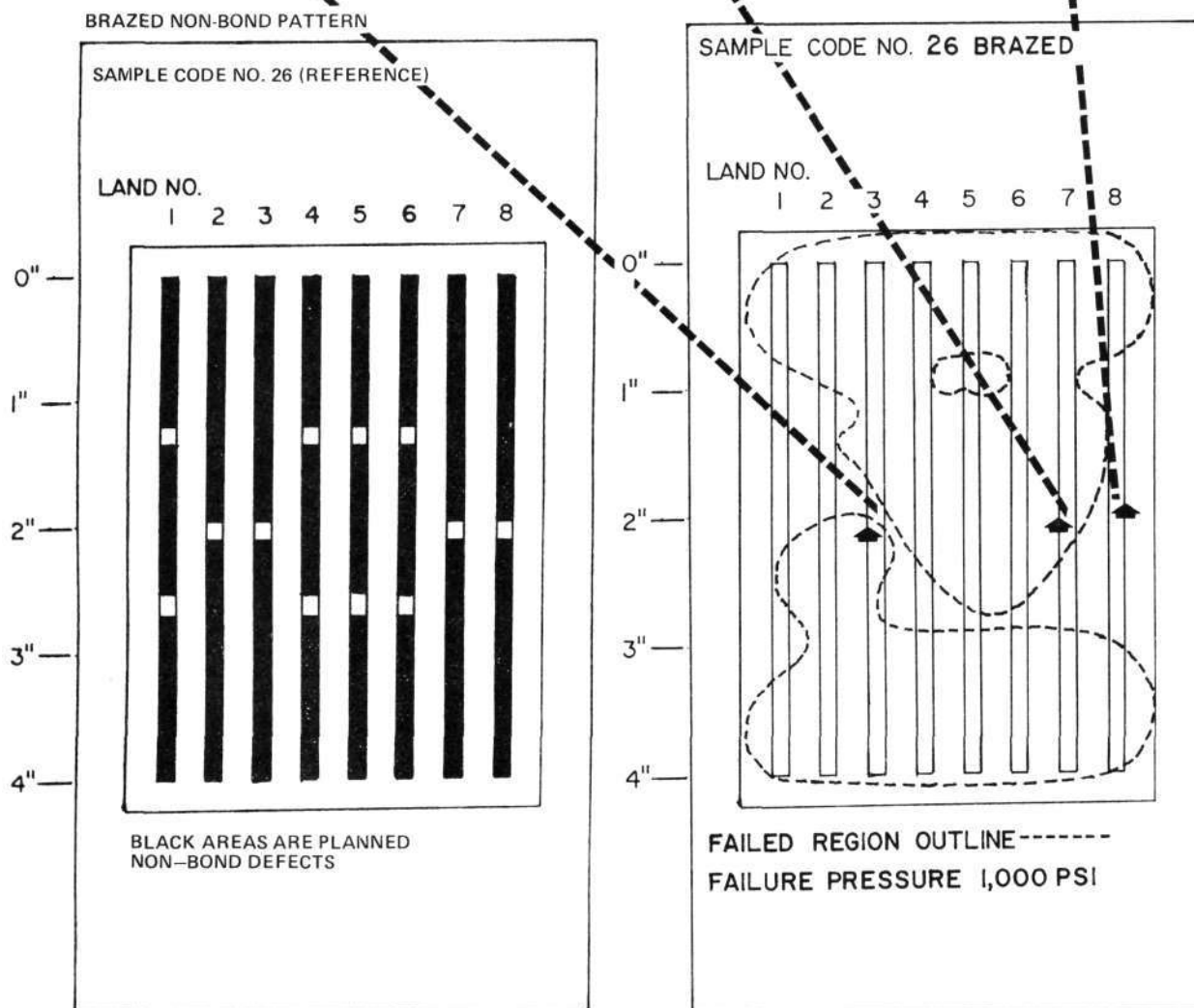
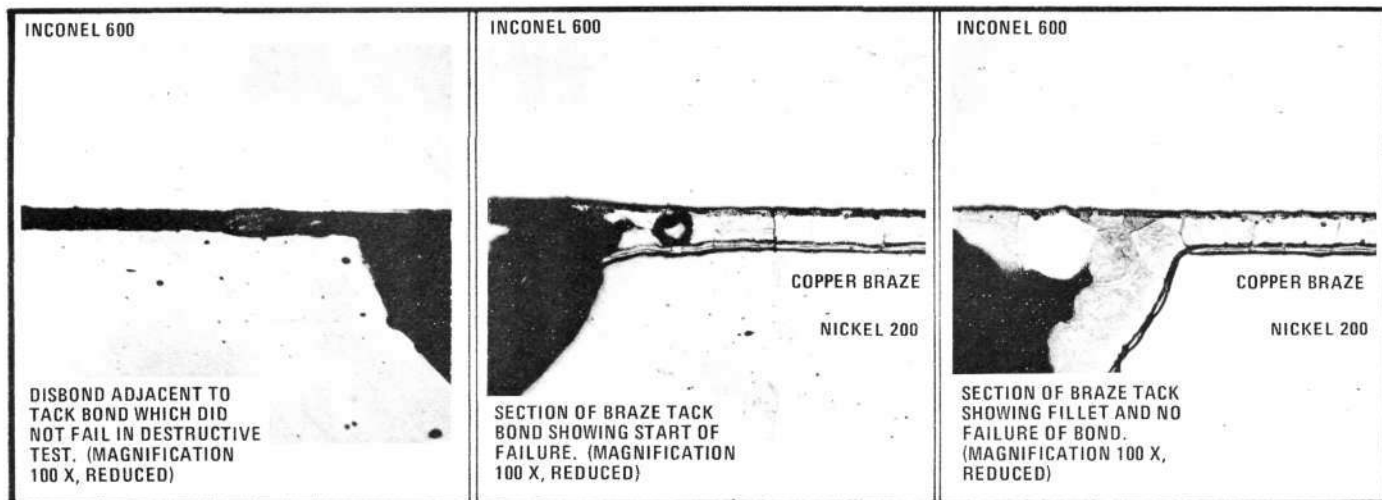


TEST PRESSURE 120 PSI

UT



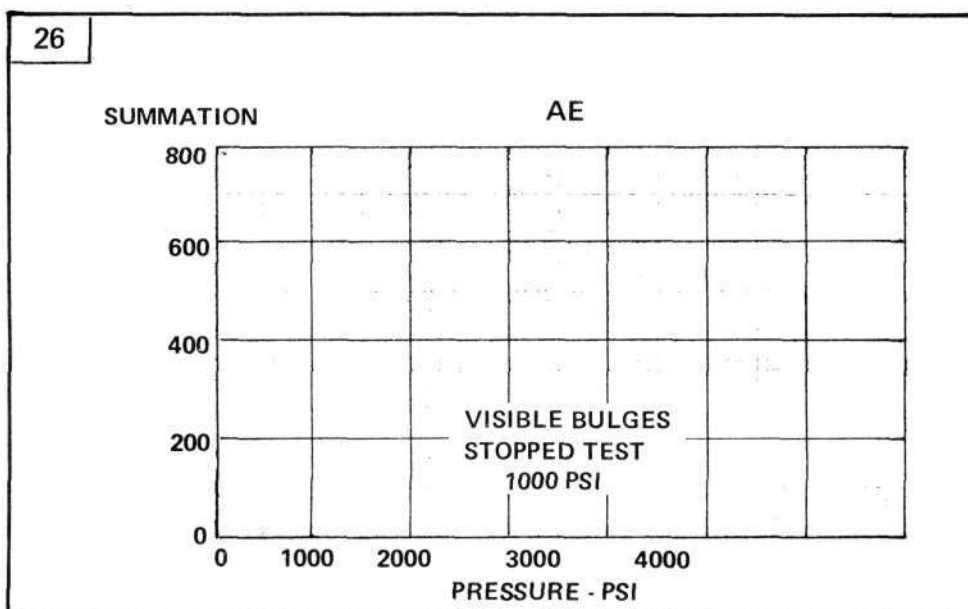




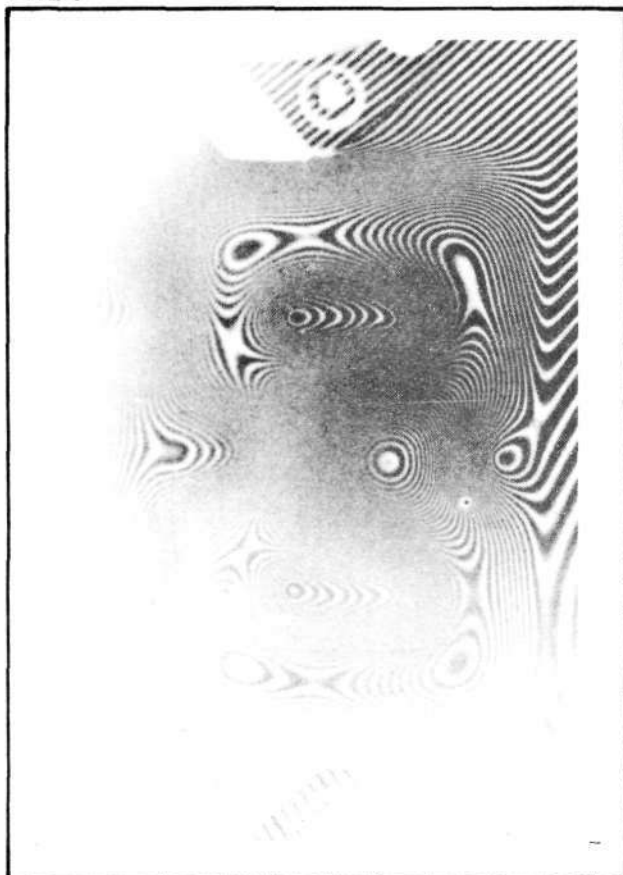
TEST RESULTS FOR BRAZED NON-BOND PANEL NO. 26

FIGURE A-27

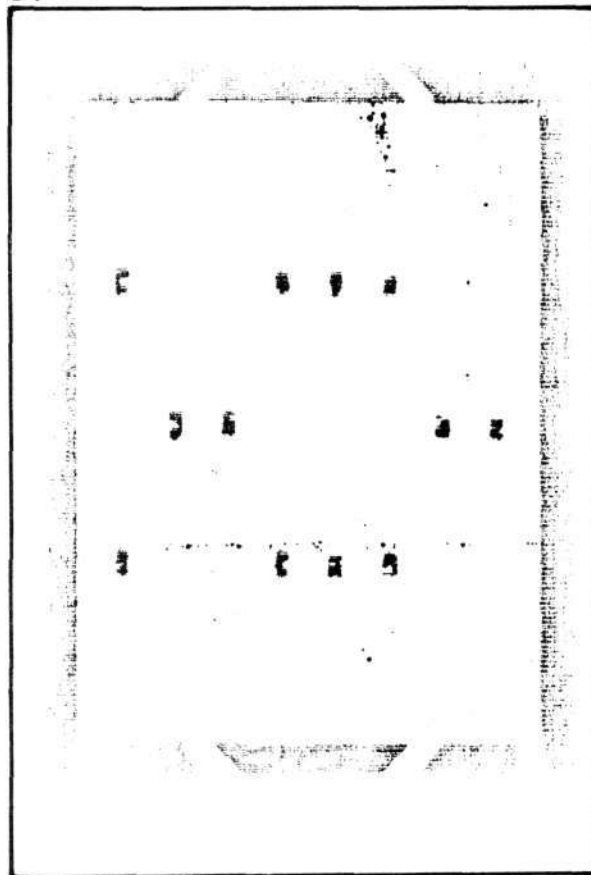
# BRAZE CONT'D



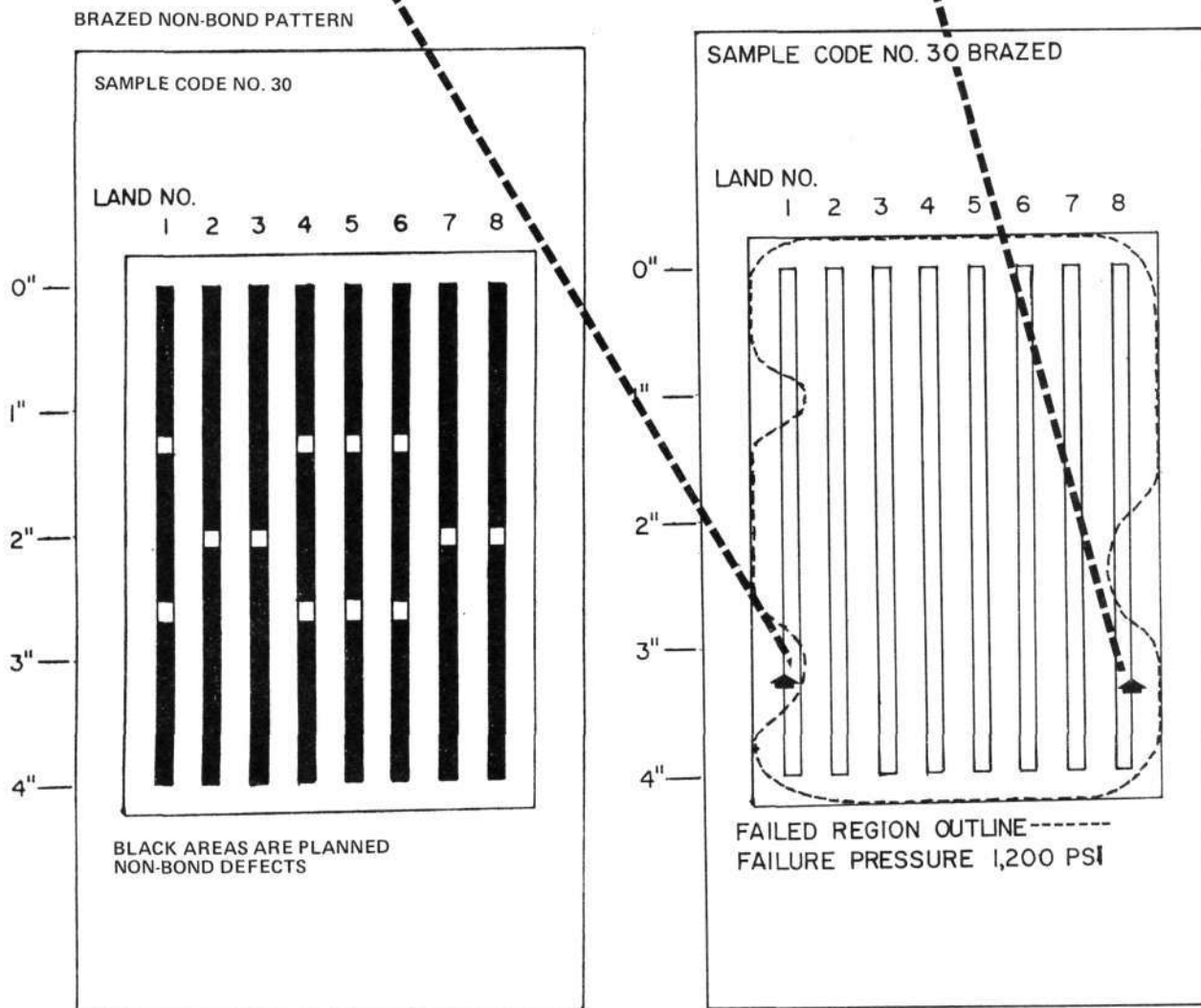
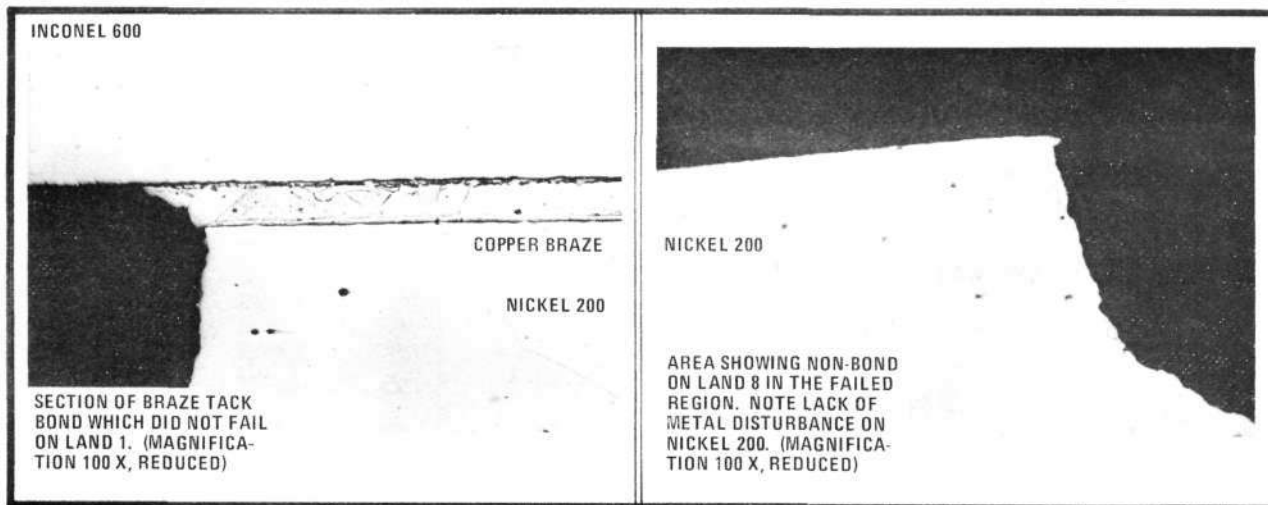
HNDT



UT



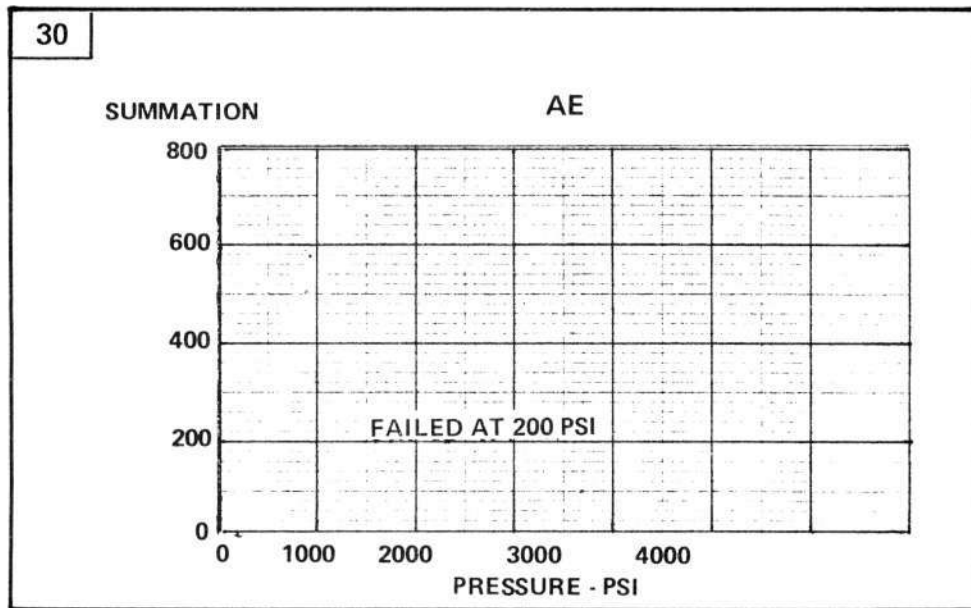
TEST PRESSURE 100 PSI



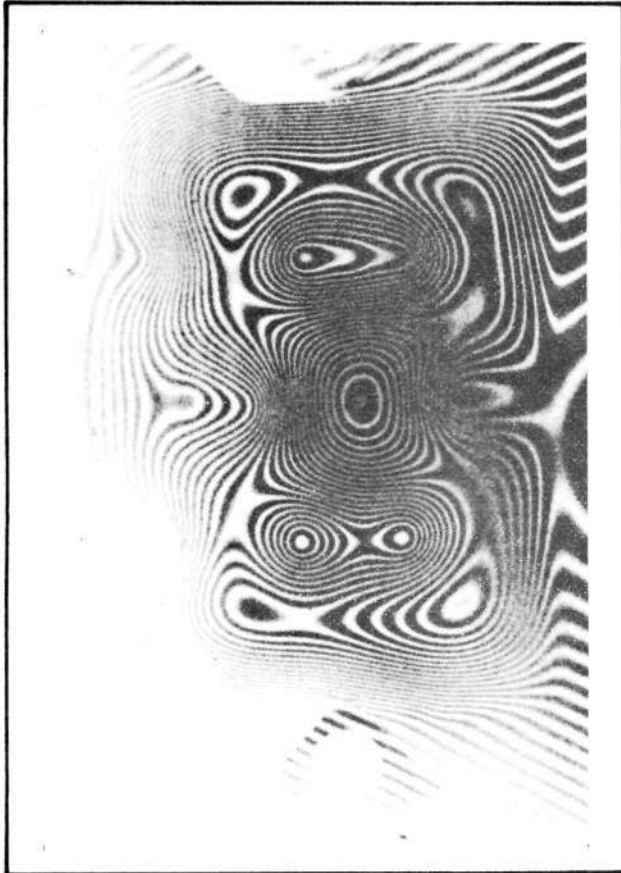
TEST RESULTS ON BRAZED NON-BOND PANEL NO. 30

FIGURE A-28

BRAZE CONT'D

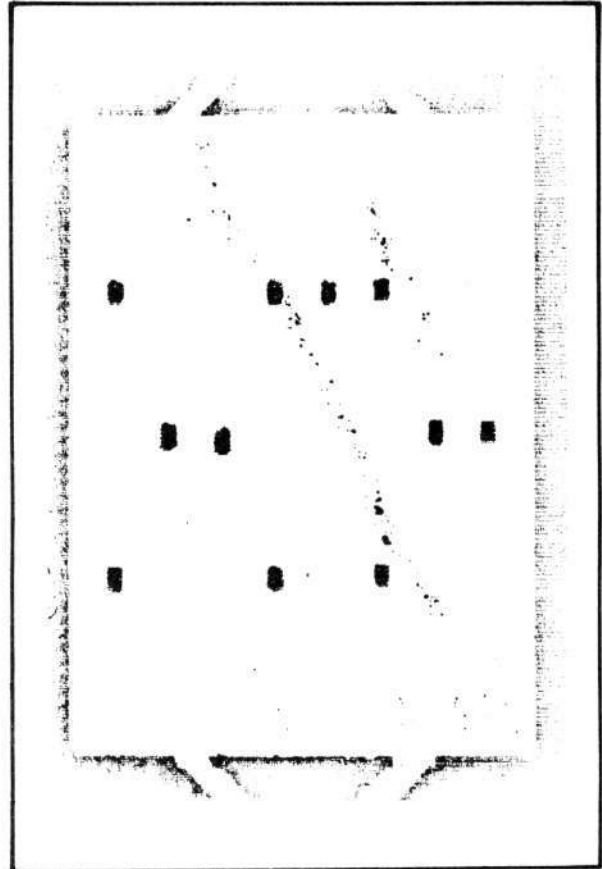


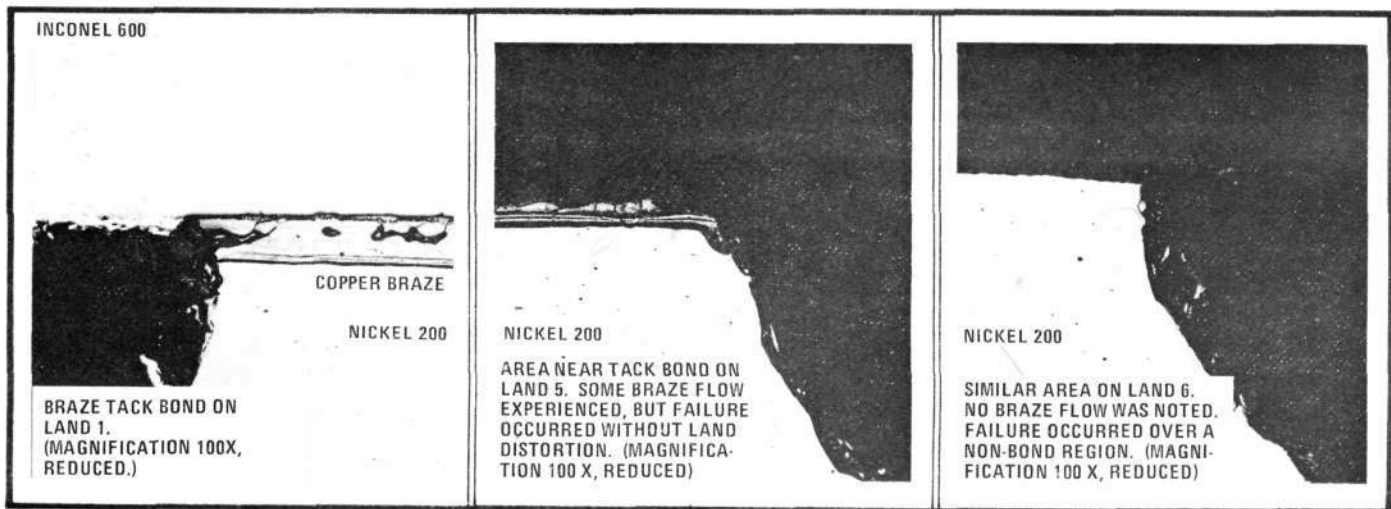
HNDT



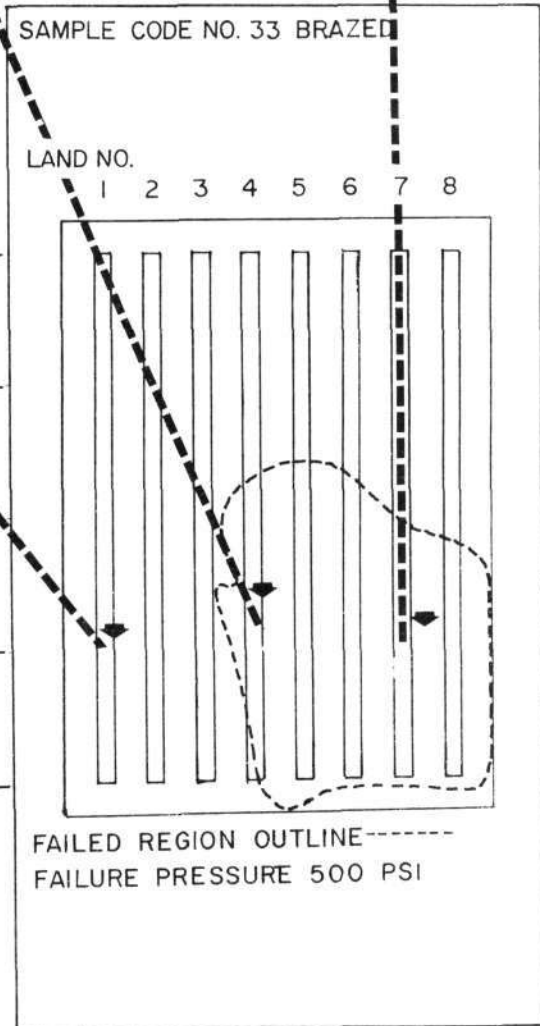
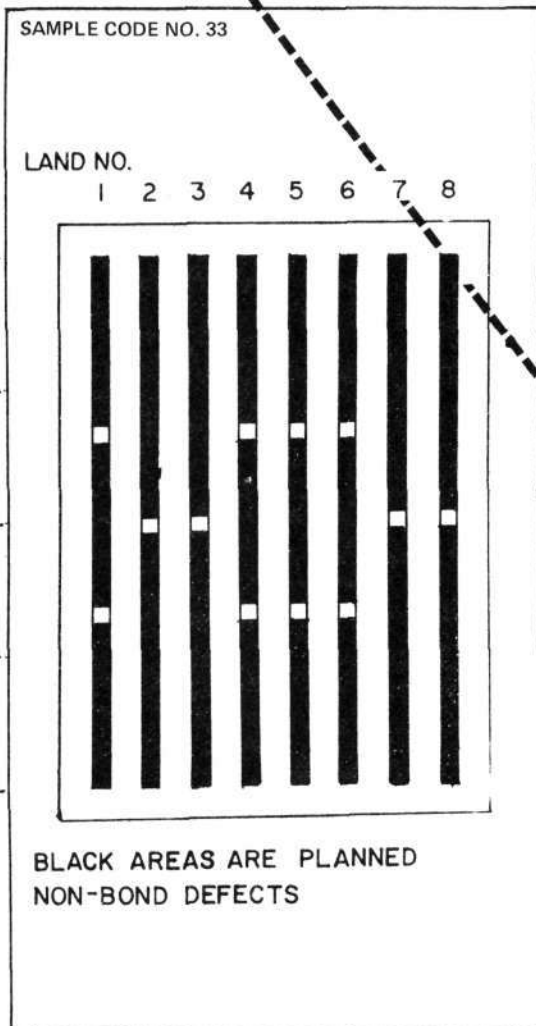
TEST PRESSURE 80 PSI

UT





# BRAZED NON-BOND PATTERN

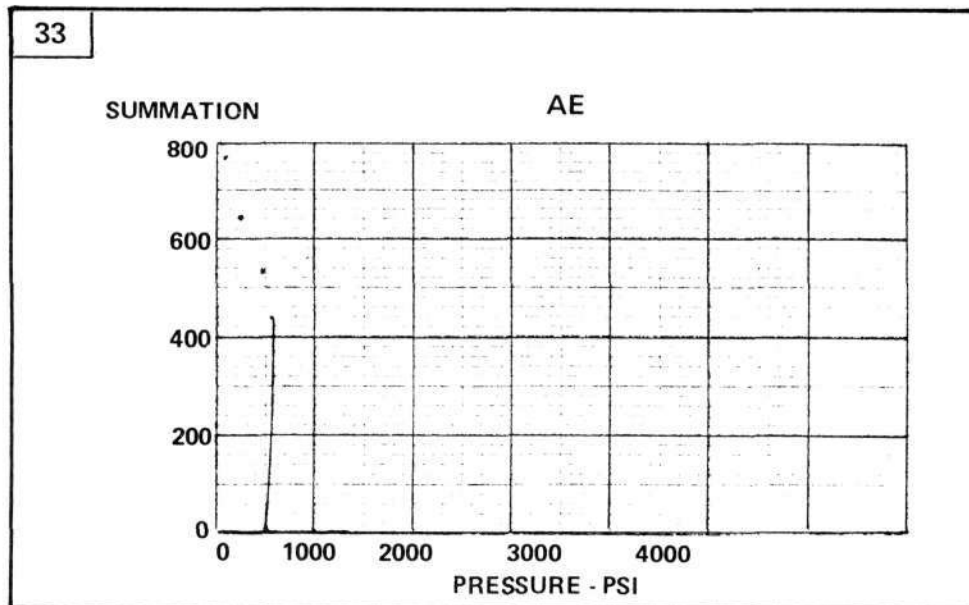


TEST RESULTS ON BRAZED NON-BOND PANEL NO. 33

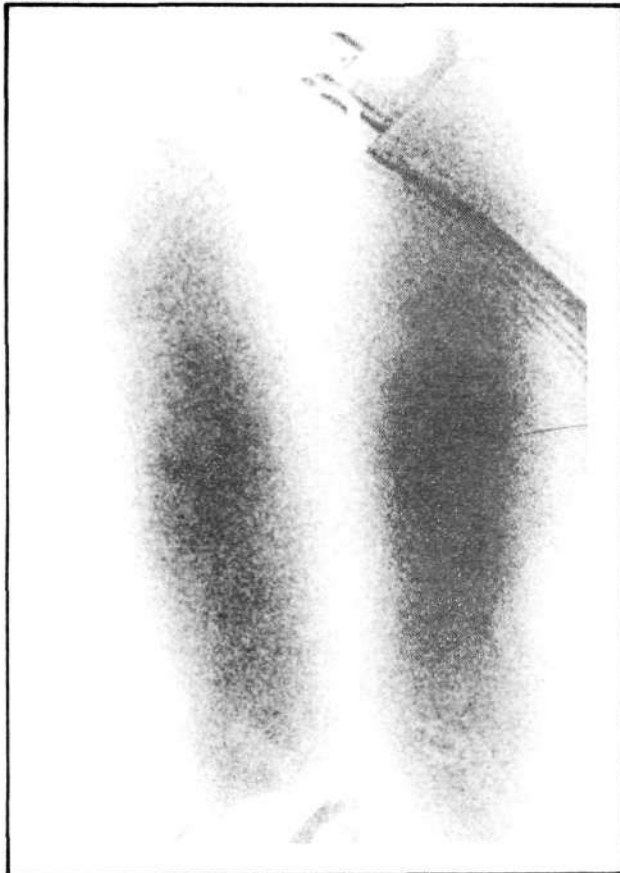
FIGURE A-29



BRAZE CONT'D

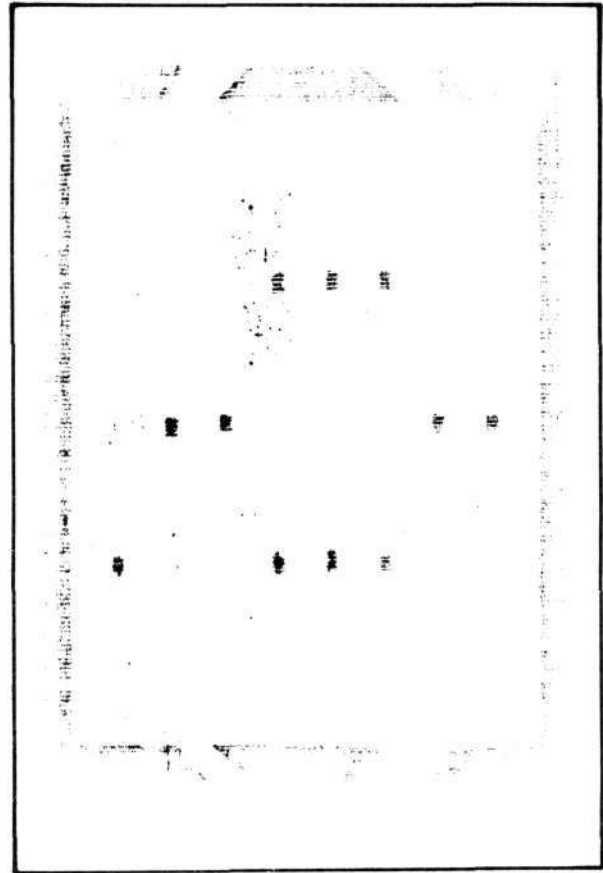


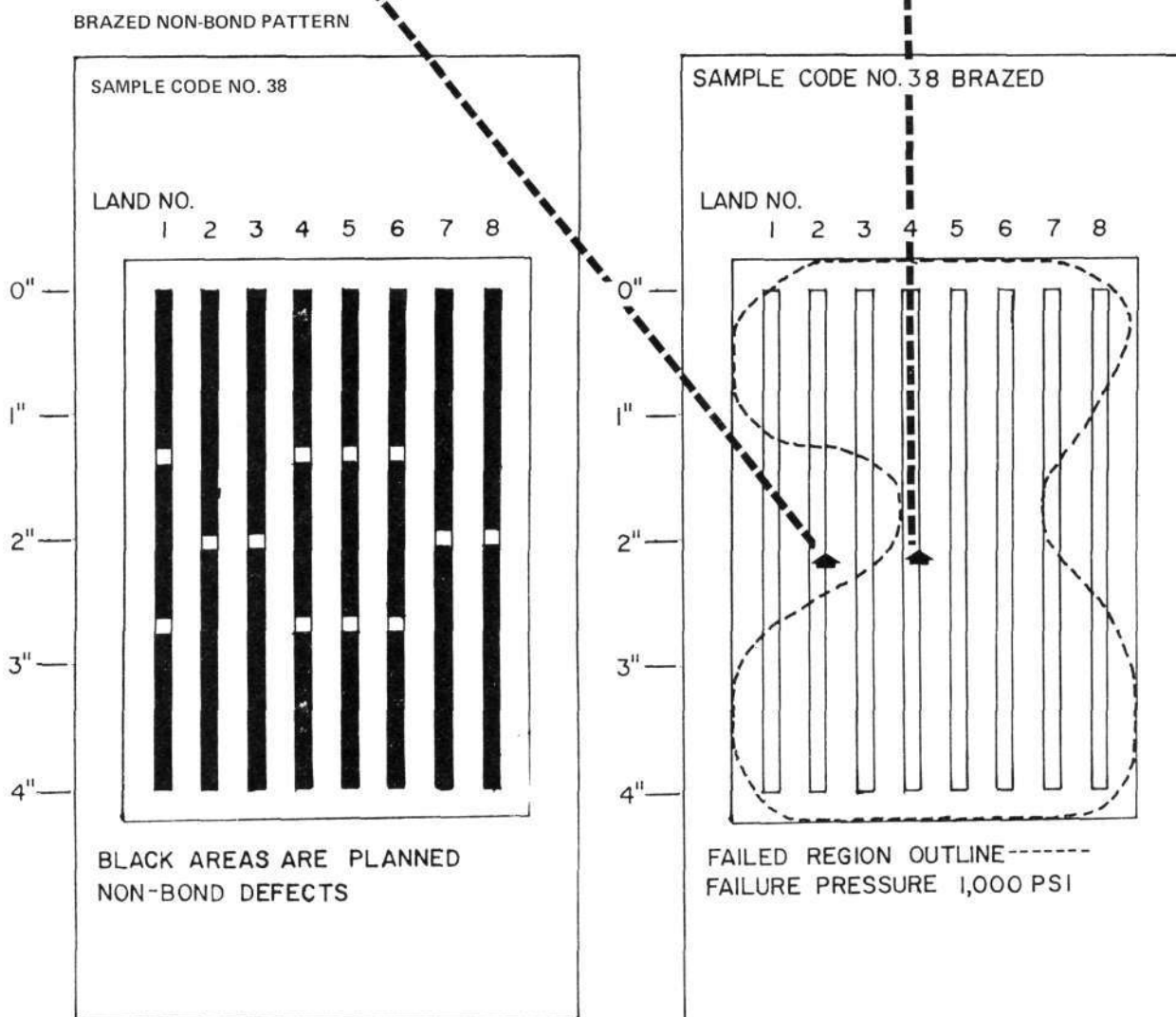
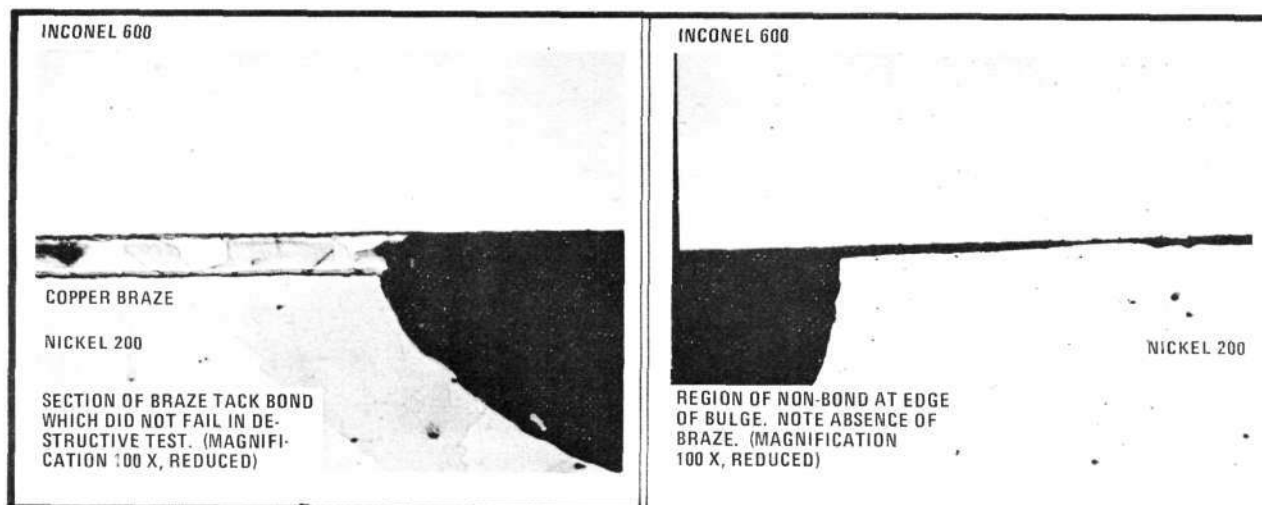
HNDT



TEST PRESSURE 80 PSI

UT

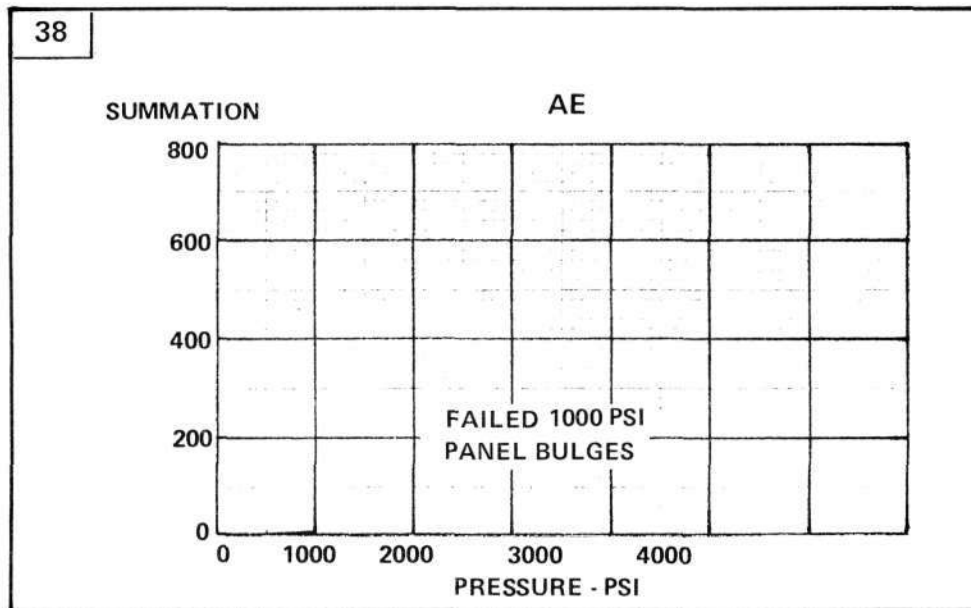




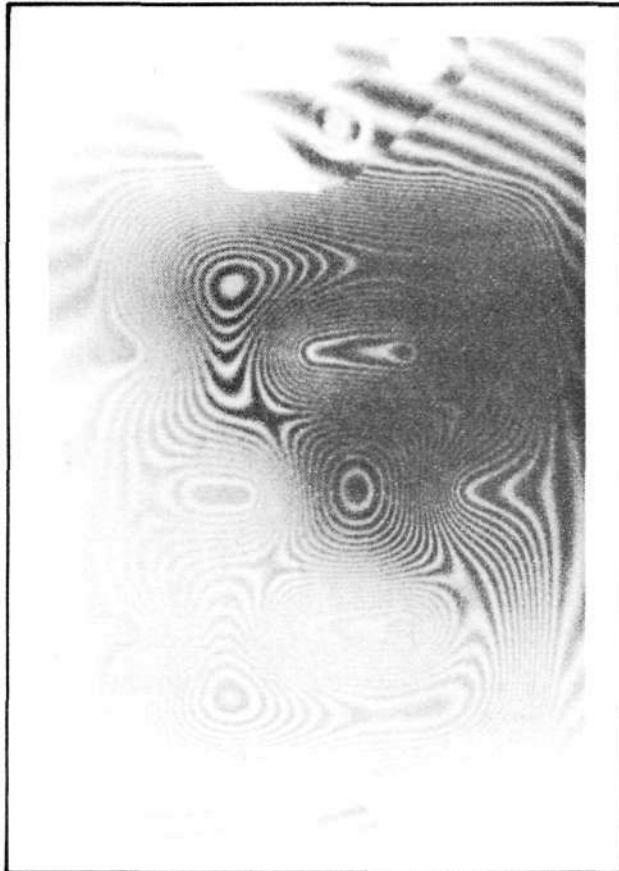
TEST RESULTS ON BRAZED NON-BOND PANEL NO. 38

FIGURE A-30

BRAZE CONT'D

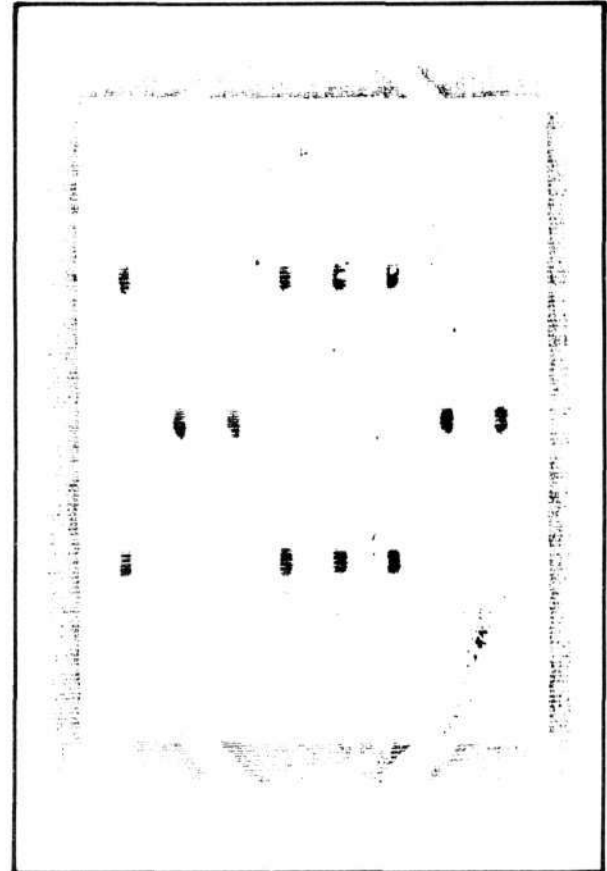


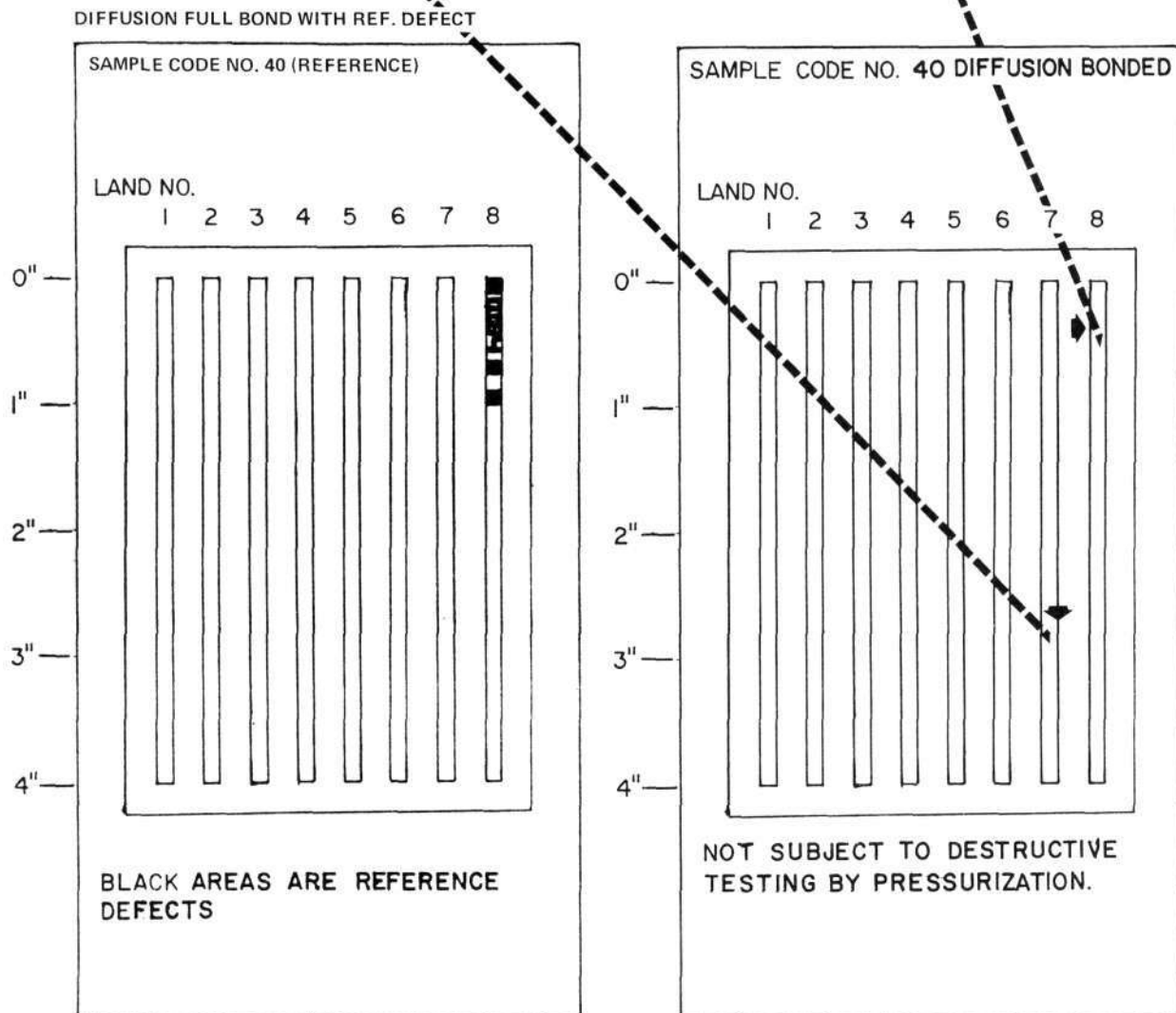
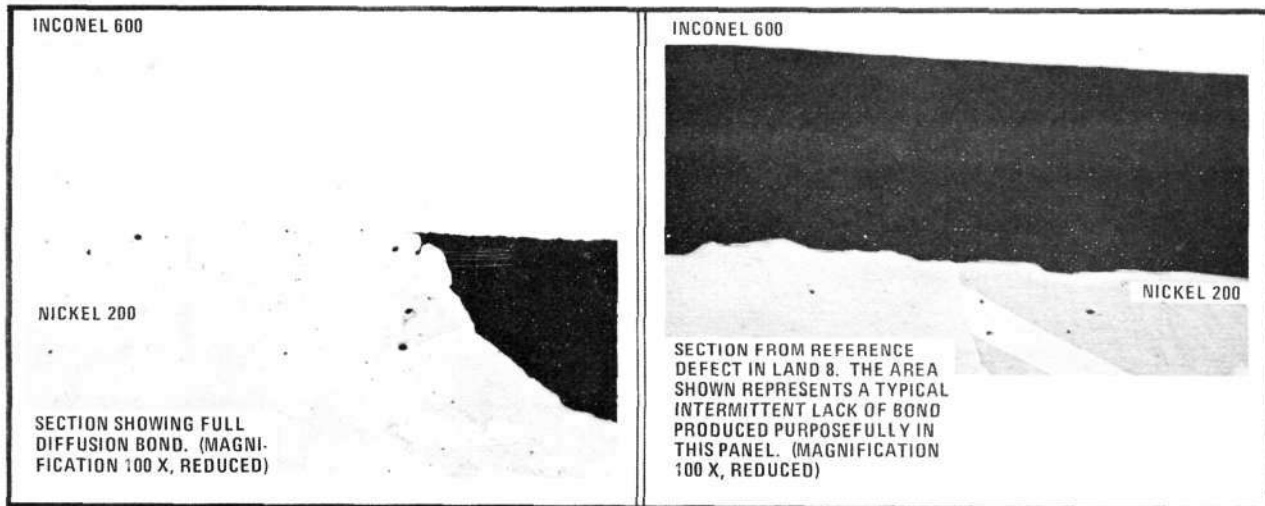
HNDT



TEST PRESSURE 90 PSI

UT





TEST RESULTS ON DIFFUSION FULL BOND PANEL NO. 40

FIGURE A-31

# DIFFUSION CONT'D

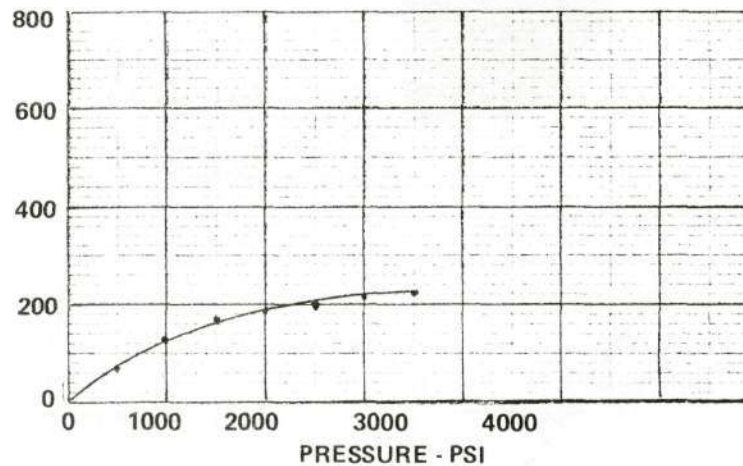
Reproduced from  
best available copy.



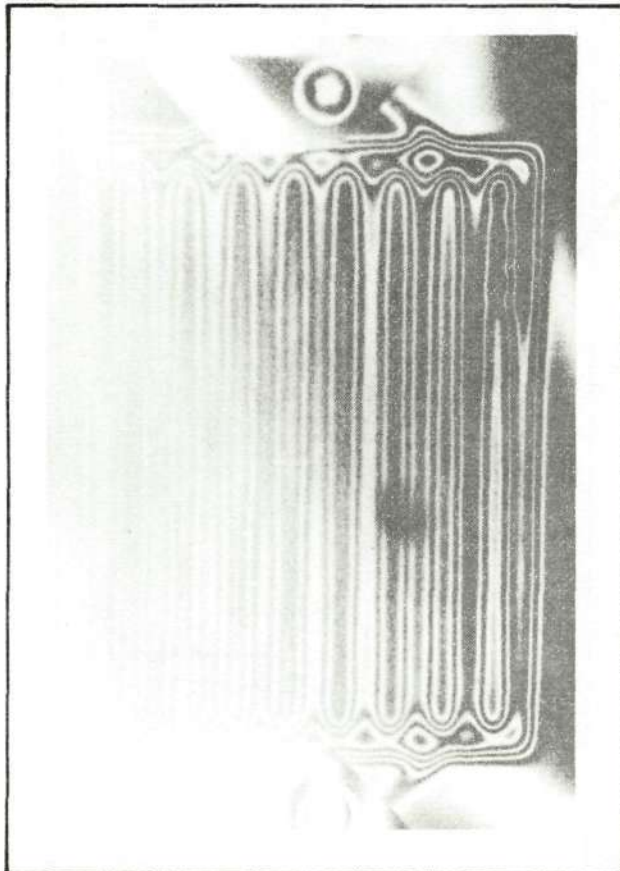
40

SUMMATION

AE

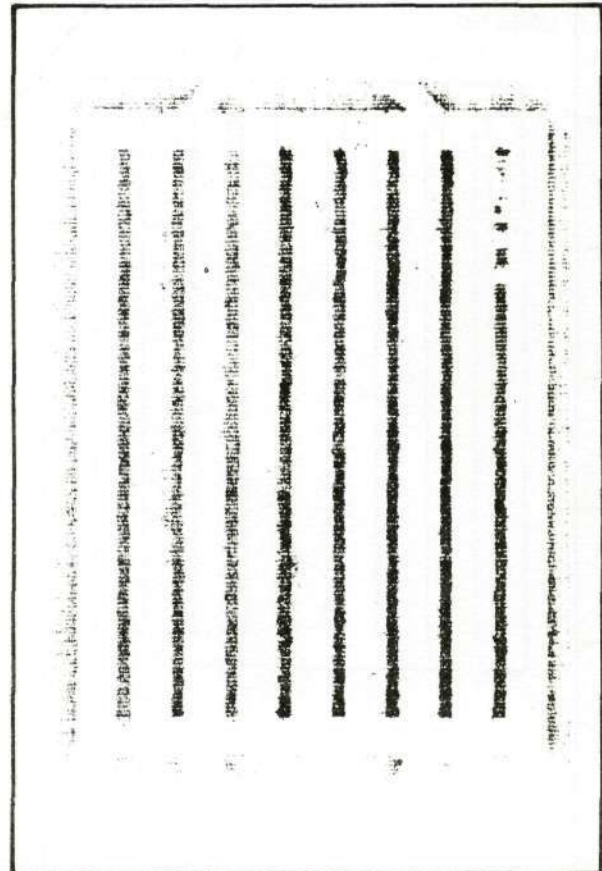


HNDT

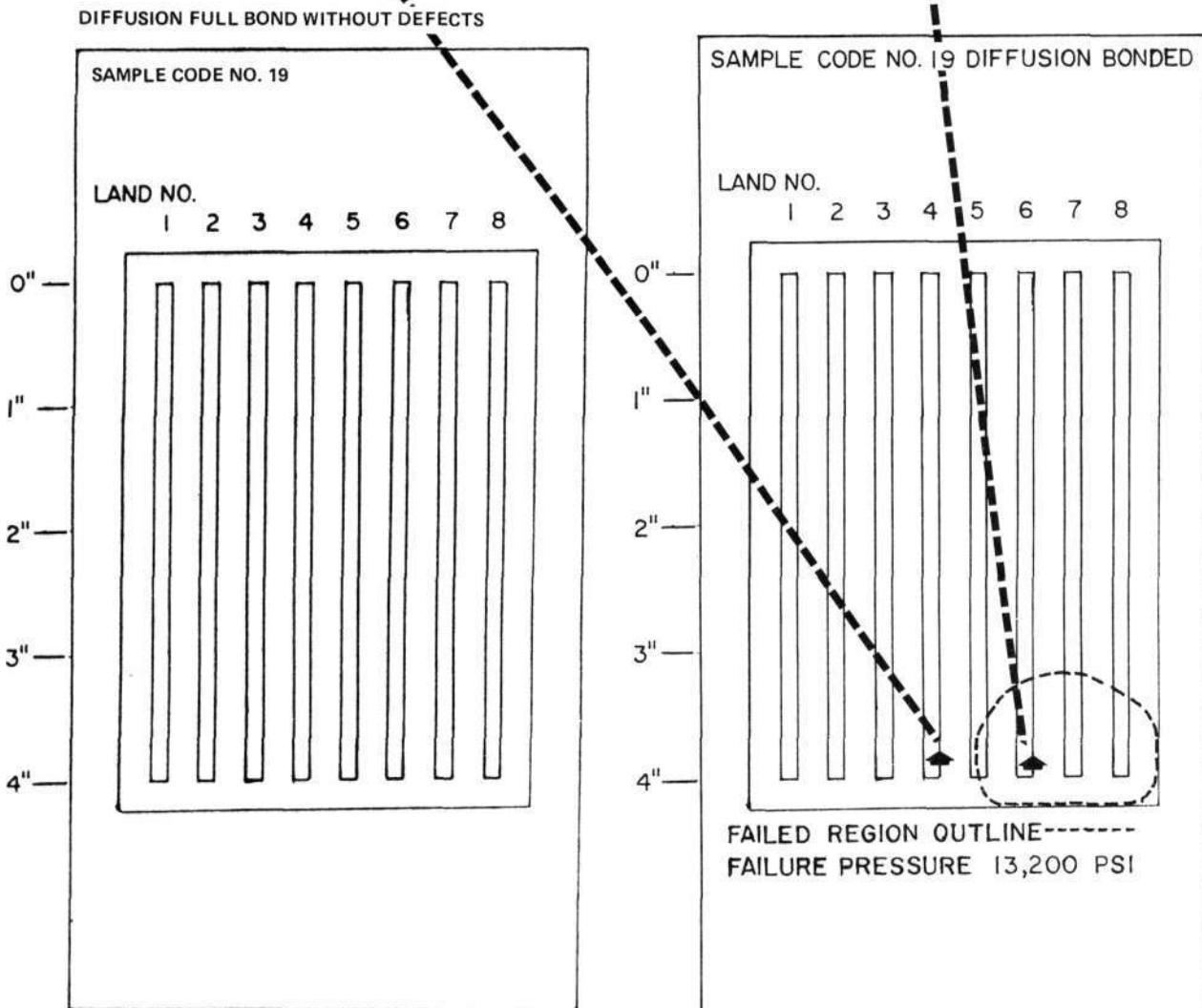
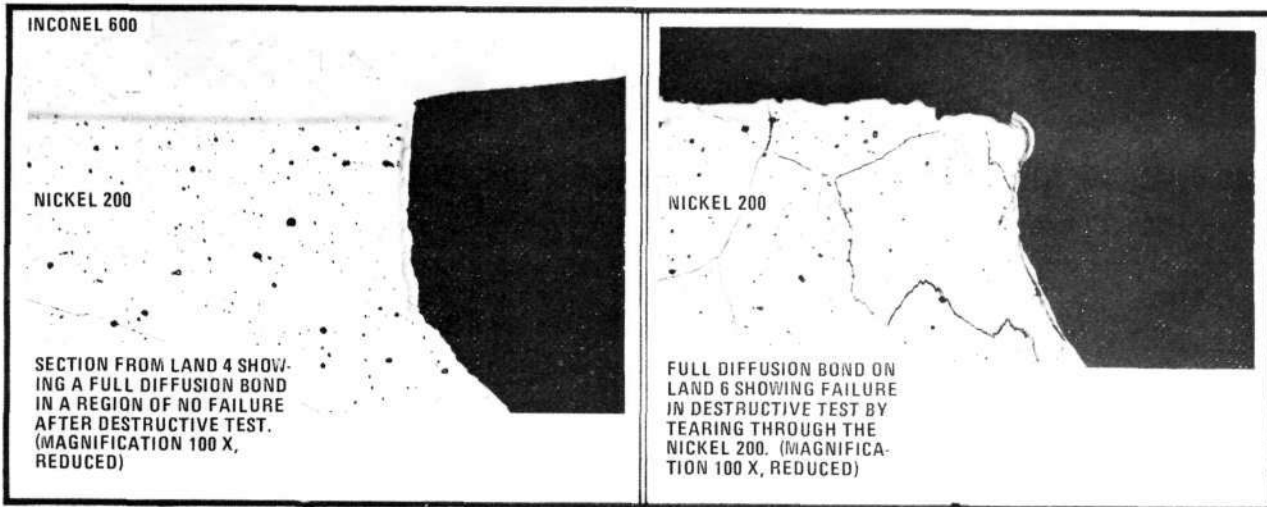


TEST PRESSURE - 1440 PSI

UT







TEST RESULTS ON DIFFUSION FULL BOND PANEL NO. 19

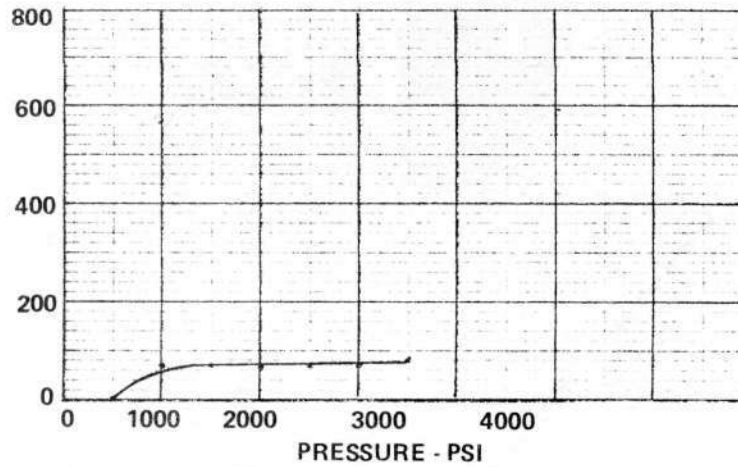
FIGURE A-32

# DIFFUSION NDE RESULTS

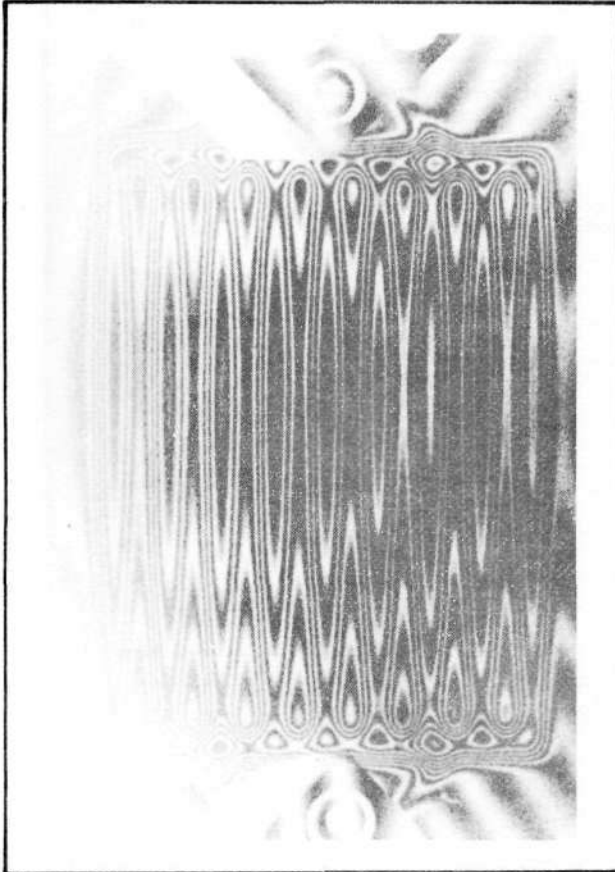
19

SUMMATION

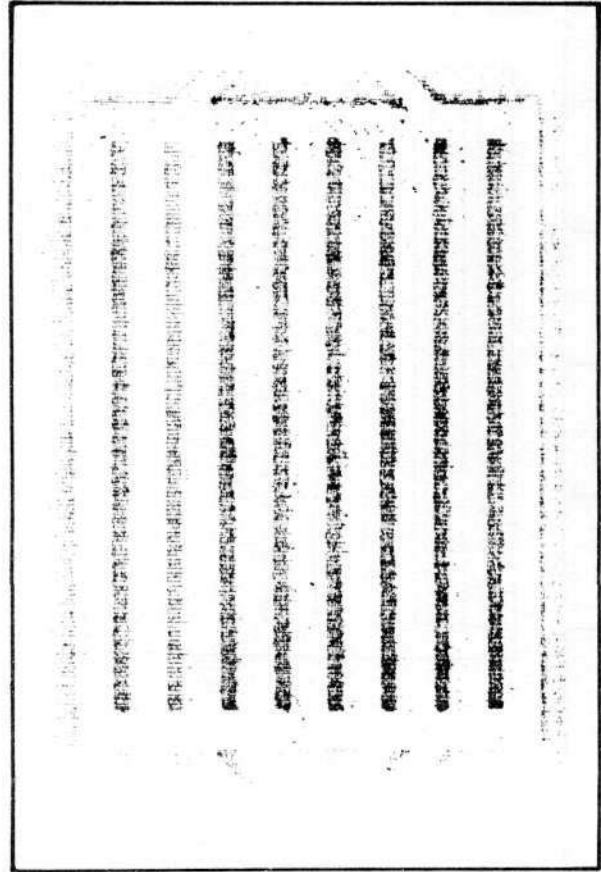
AE



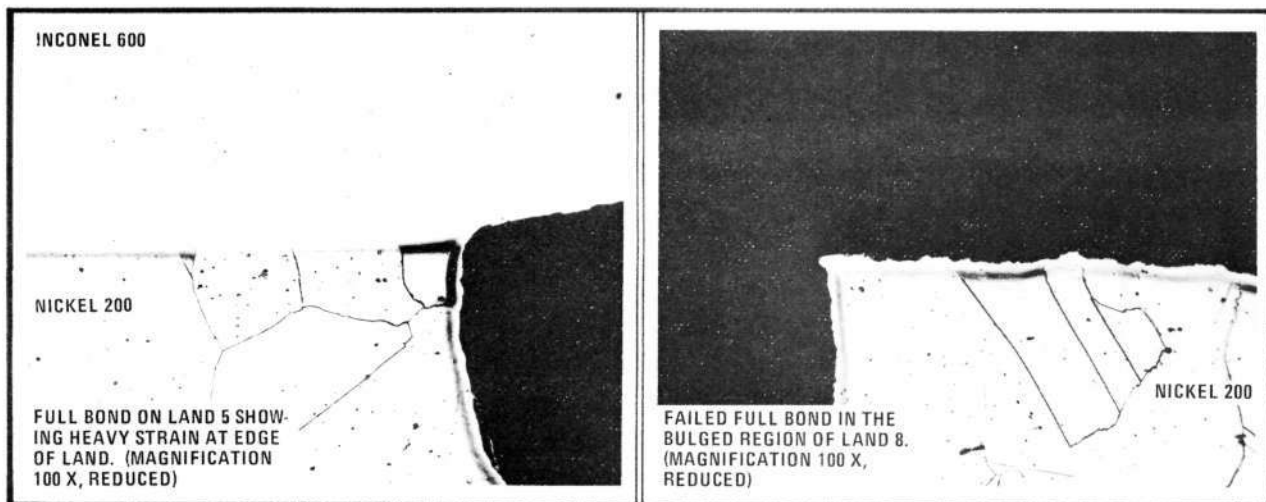
HNDT



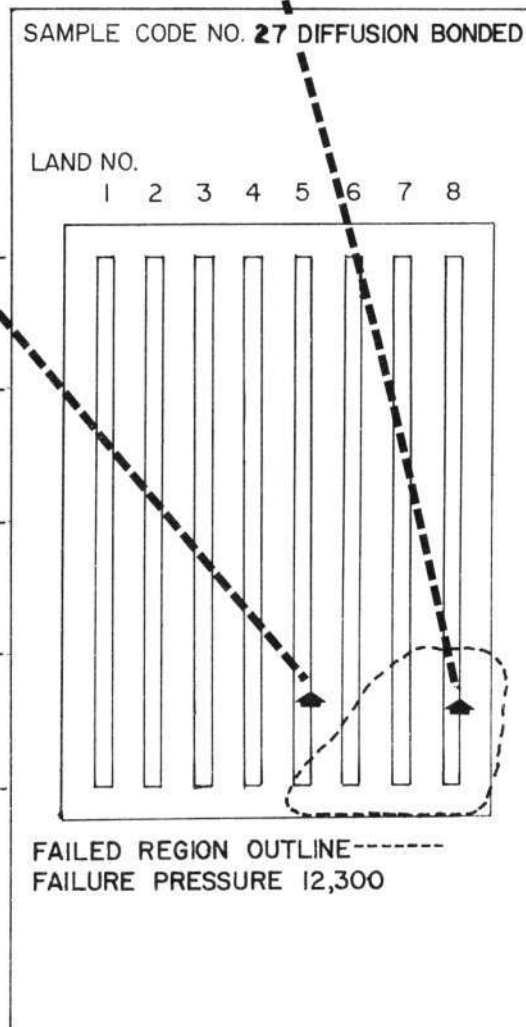
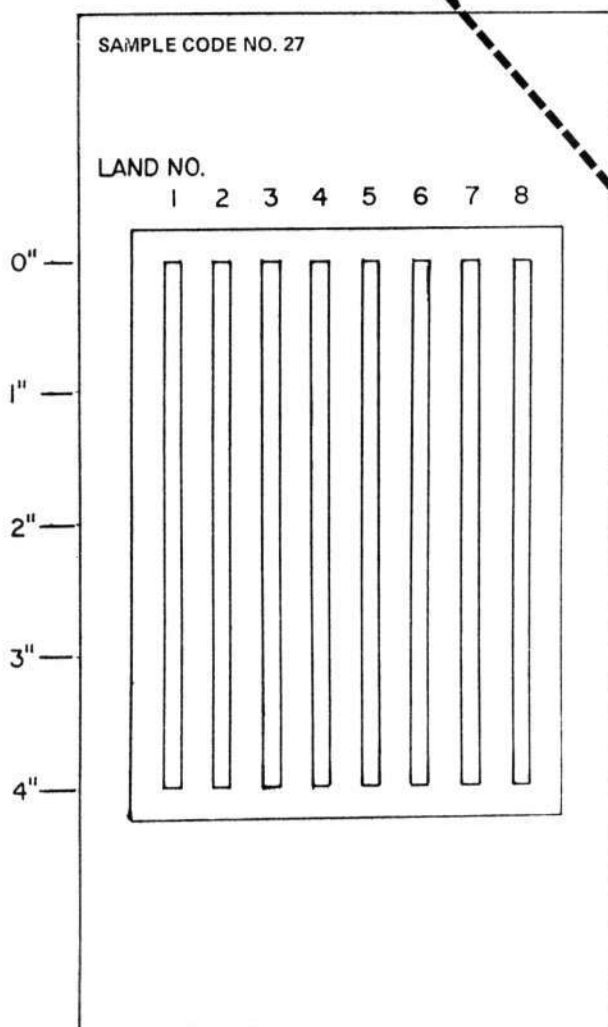
UT



TEST PRESSURE 1450 PSI



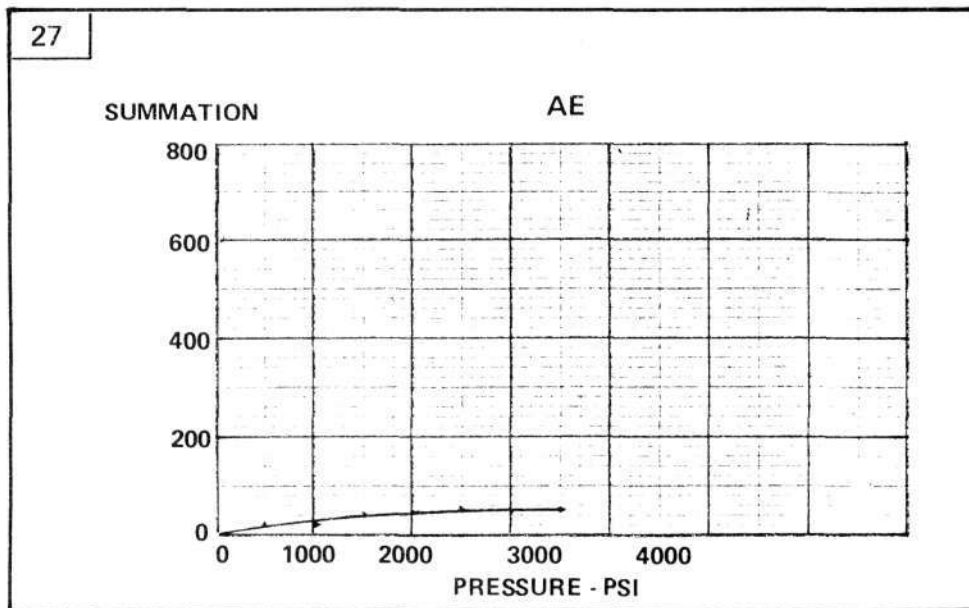
# DIFFUSION FULL BOND WITHOUT DEFECTS



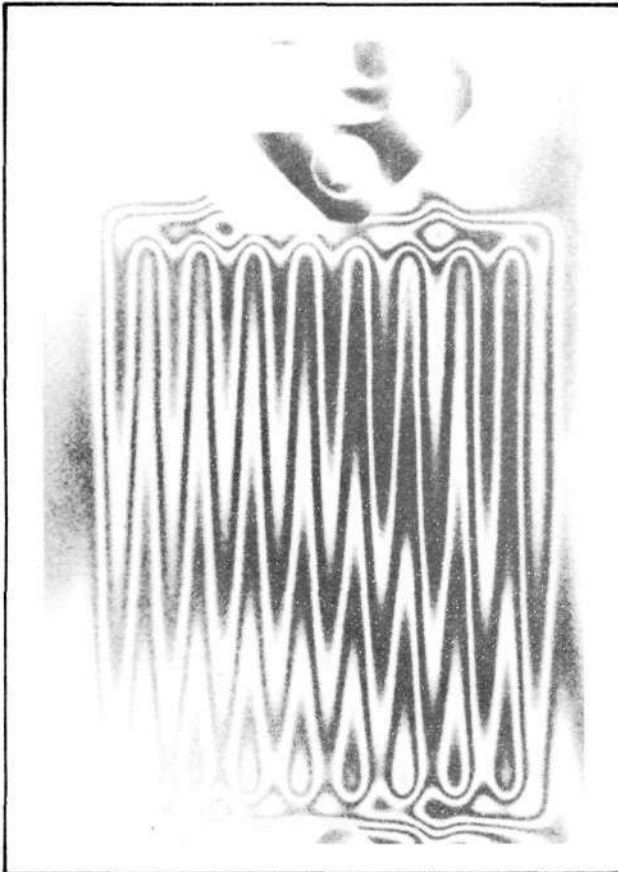
TEST RESULTS ON DIFFUSION FULL BOND PANEL NO. 27

FIGURE A-33

DIFFUSION CONT'D

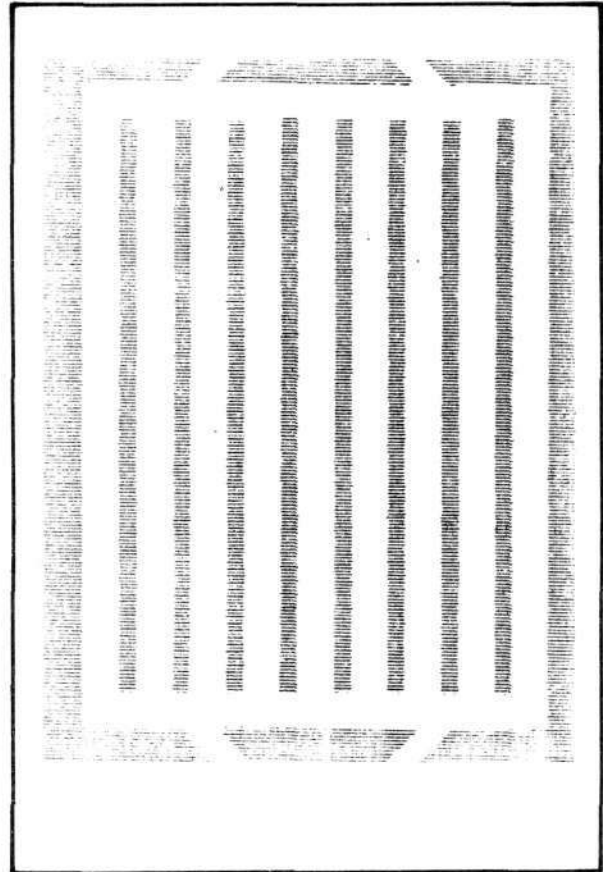


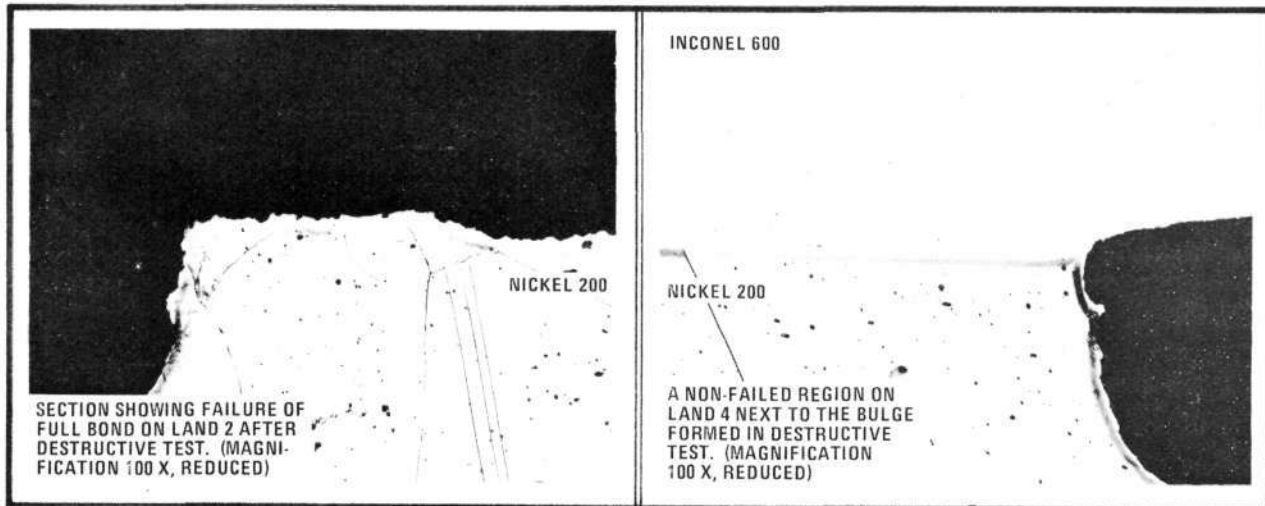
HNDT



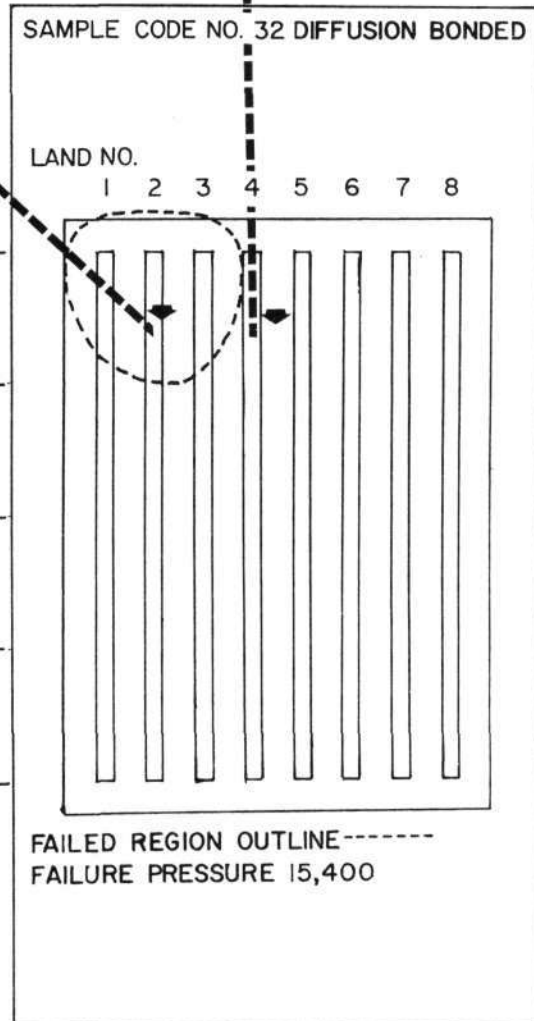
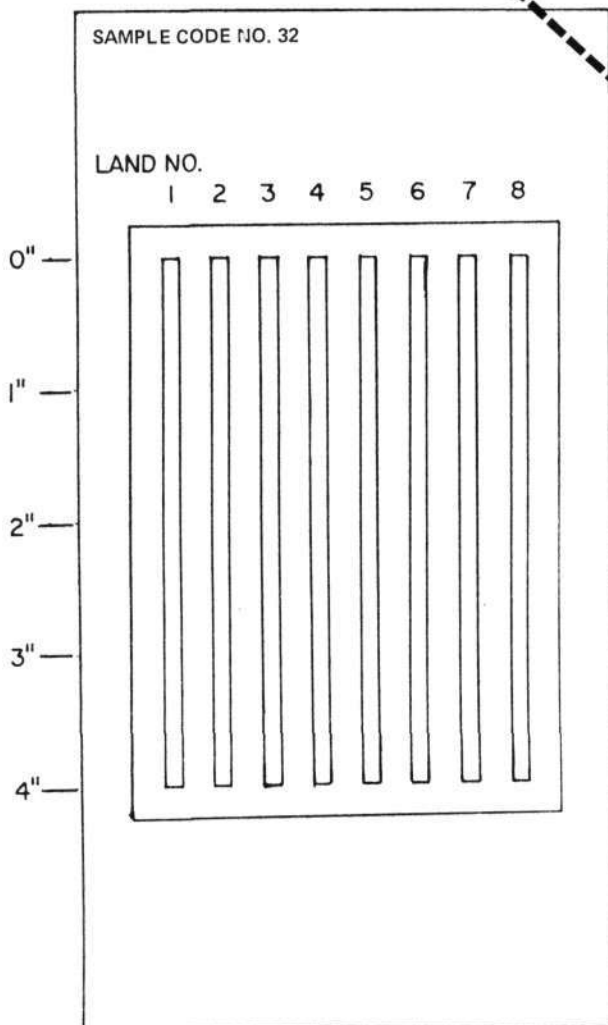
TEST PRESSURE 1380 PSI

UT





DIFFUSION FULL BOND WITHOUT DEFECTS



TEST RESULTS ON DIFFUSION FULL BOND PANEL NO. 32

FIGURE A-34

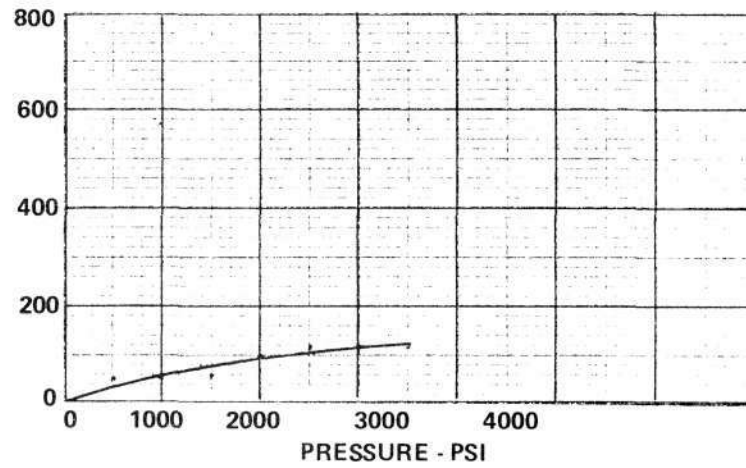


# DIFFUSION CONT'D

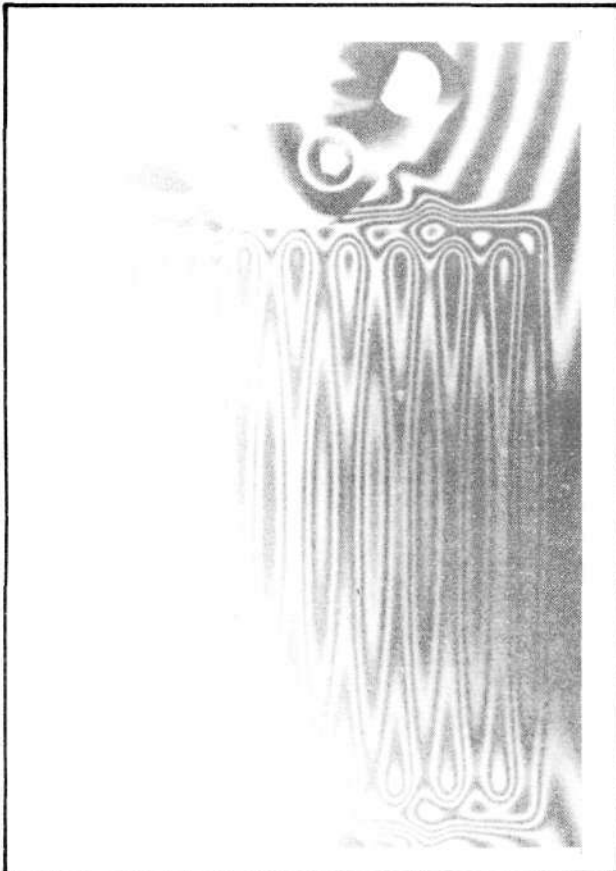
32

SUMMATION

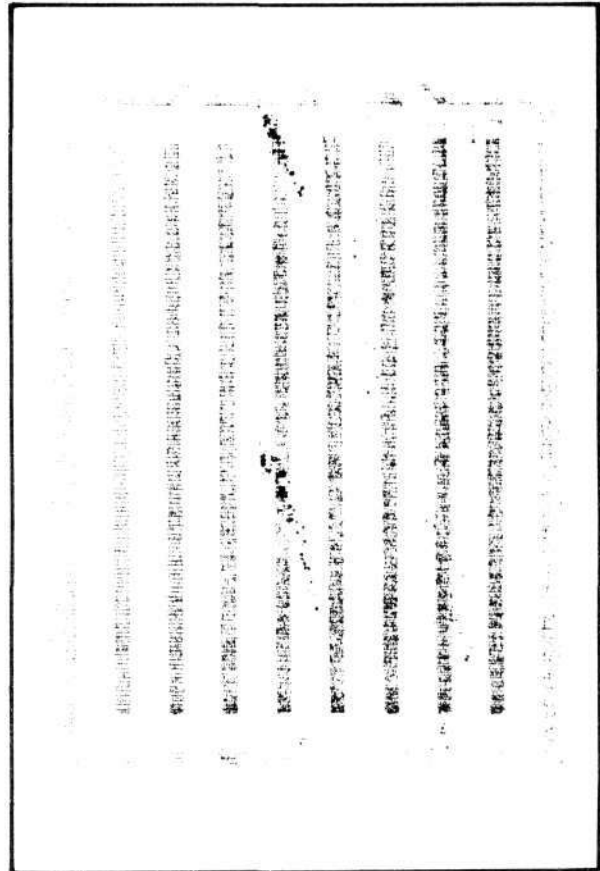
AE



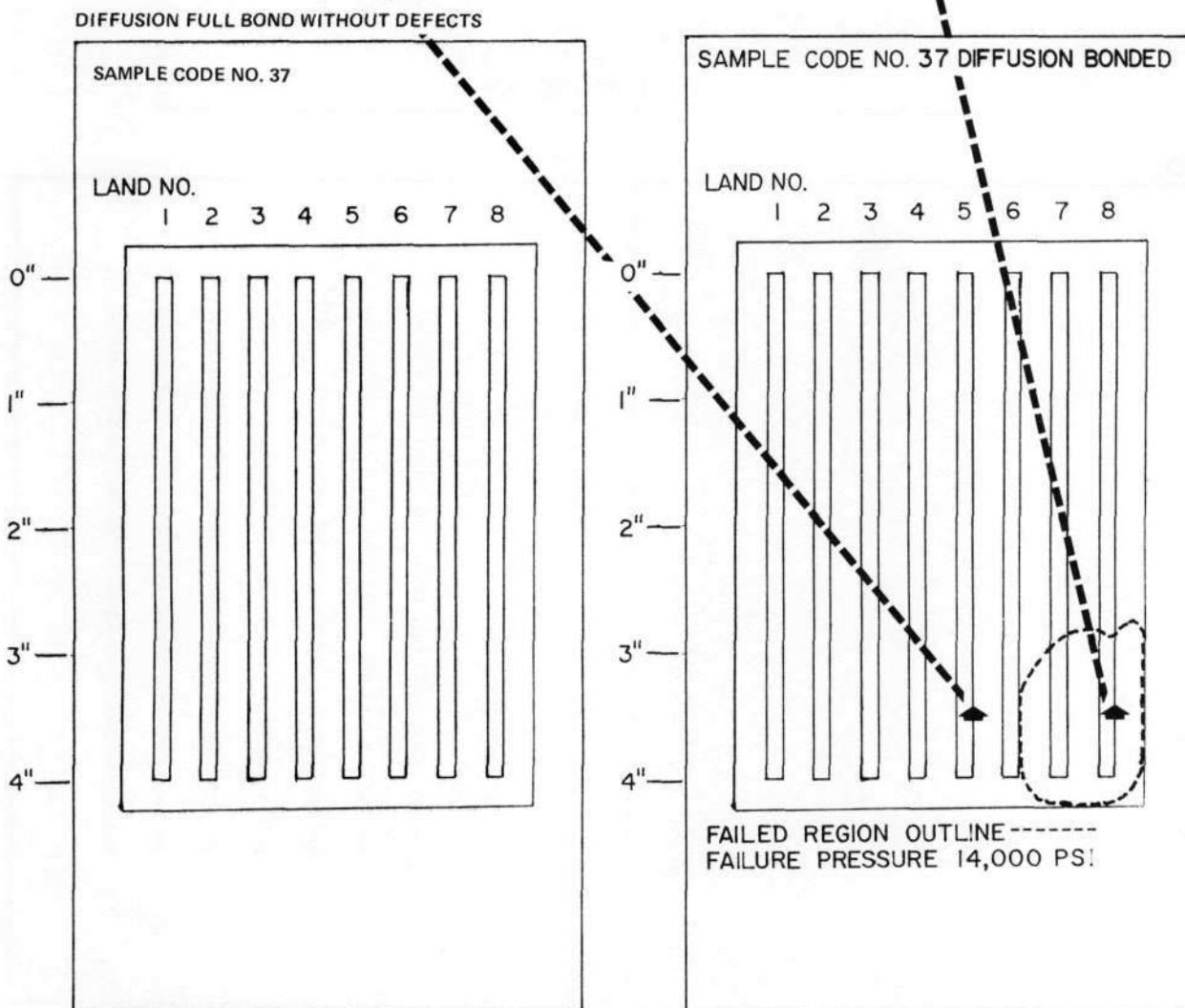
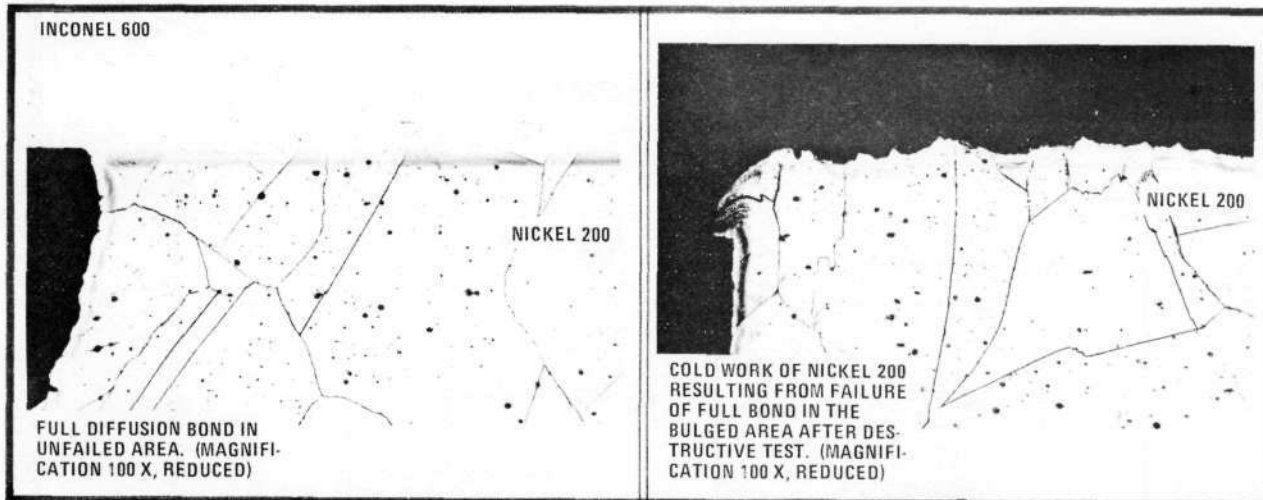
HNDT



UT



TEST PRESSURE 1440 PSI



TEST RESULTS ON DIFFUSION FULL BOND PANEL NO. 37

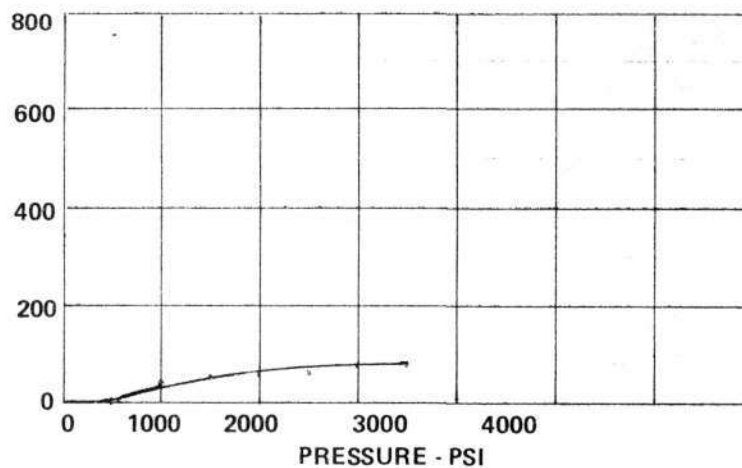
FIGURE A-35

# DIFFUSION CONT'D

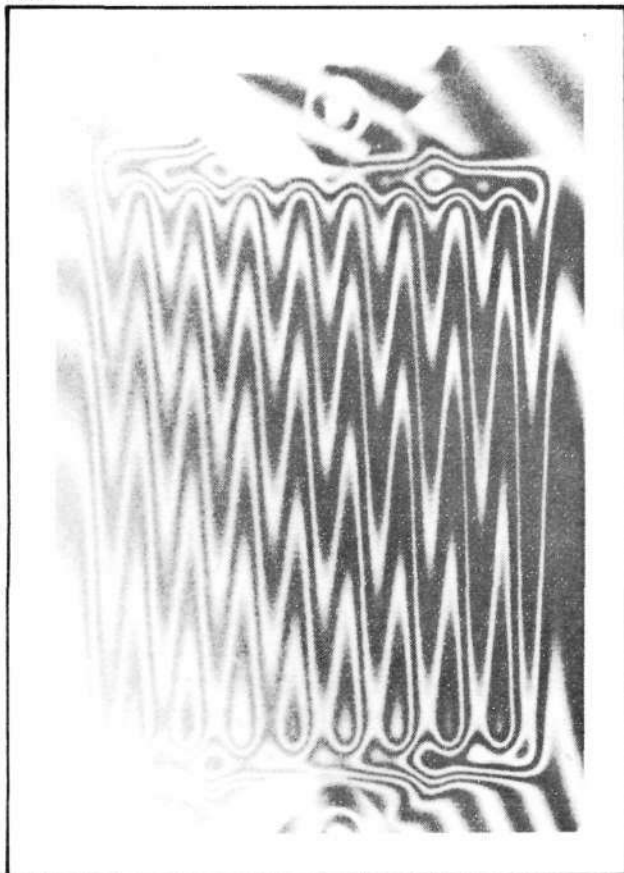
37

SUMMATION

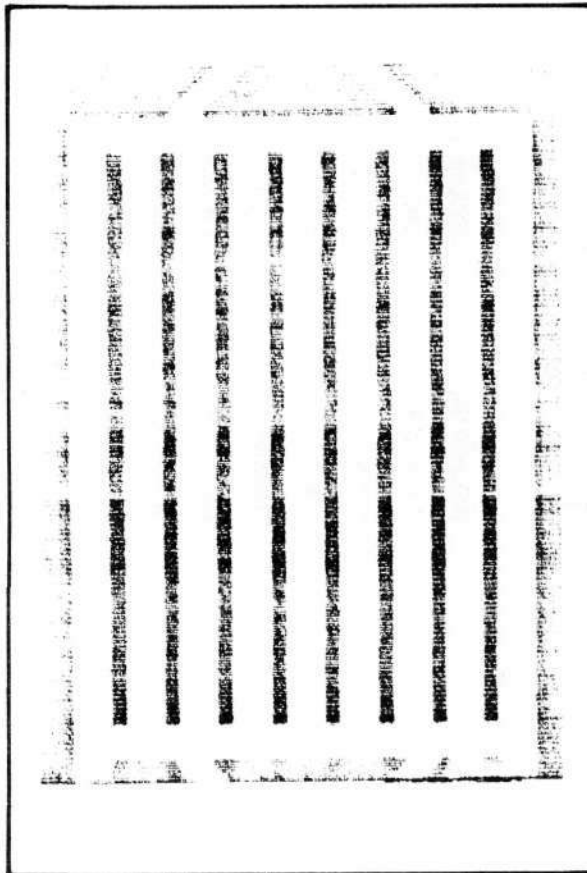
AE



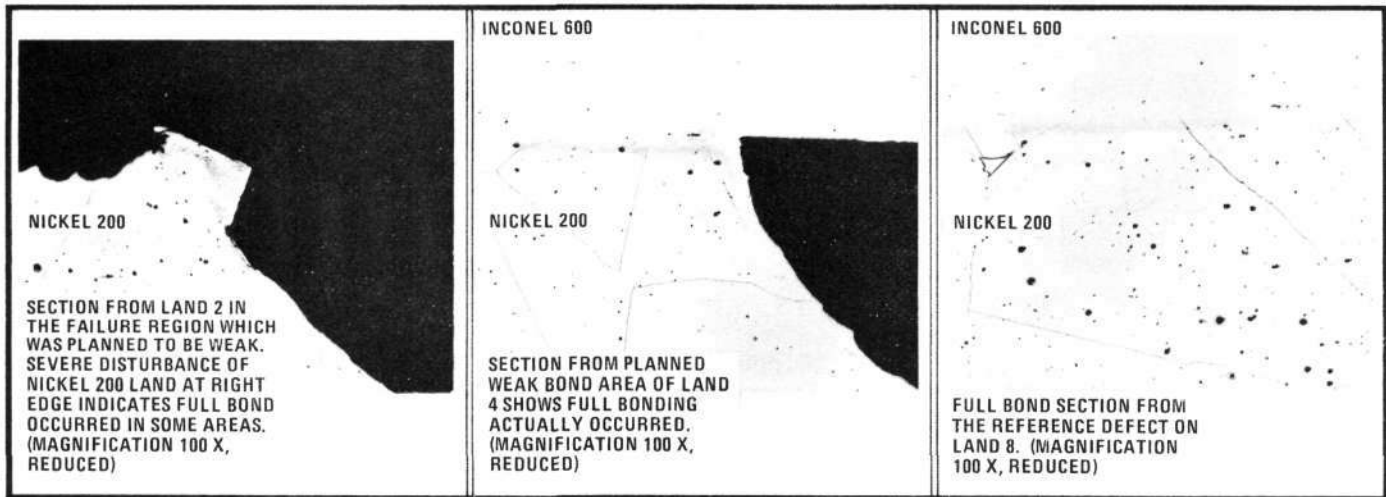
HNDT



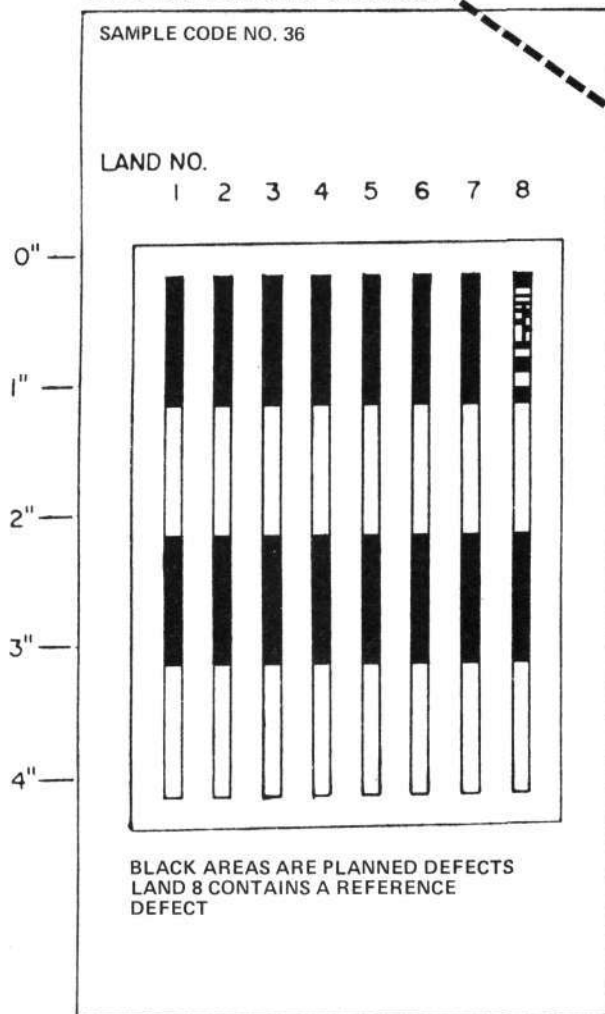
UT



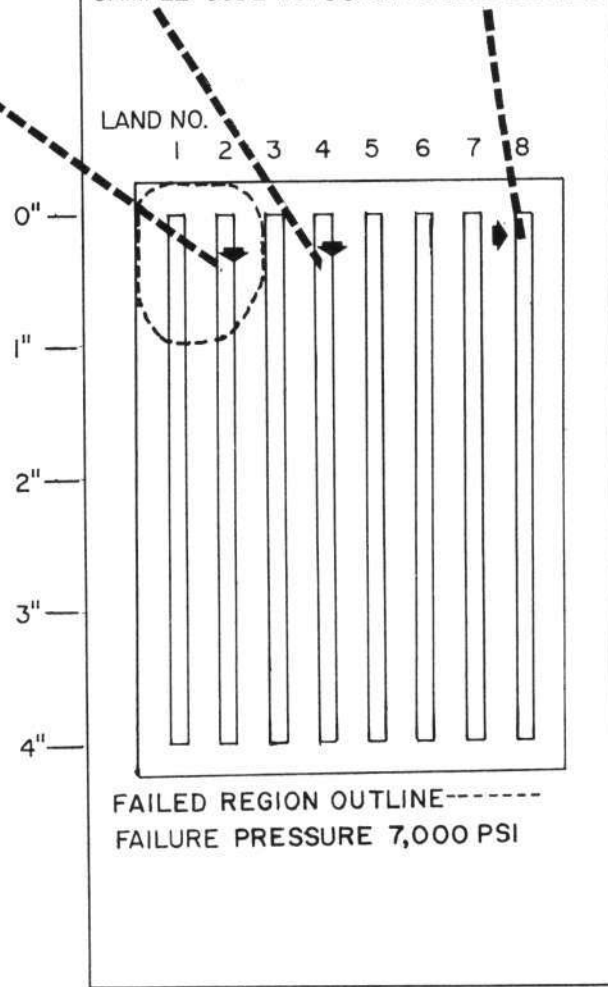
TEST PRESSURE 1380 PSI



DIFFUSION WEAK BOND—PATTERN 1



SAMPLE CODE NO. 36 DIFFUSION BONDED

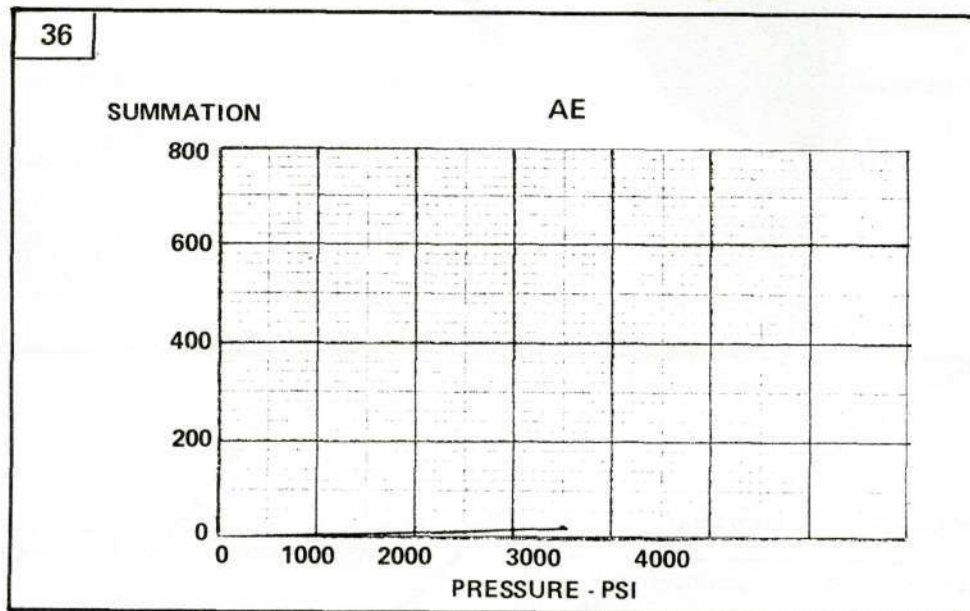


TEST RESULTS ON DIFFUSION WEAK BOND PANEL NO. 36

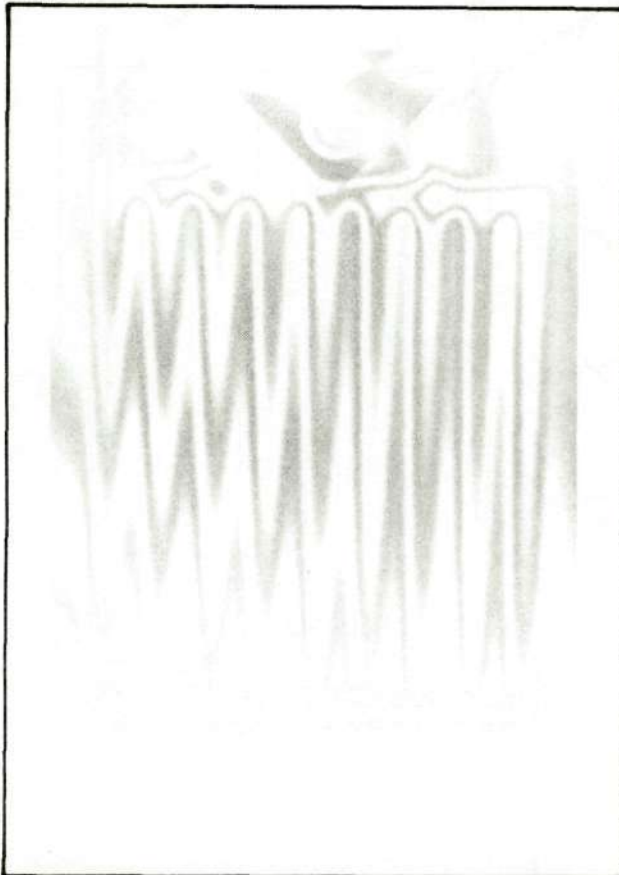
FIGURE A-36

# DIFFUSION CONT'D

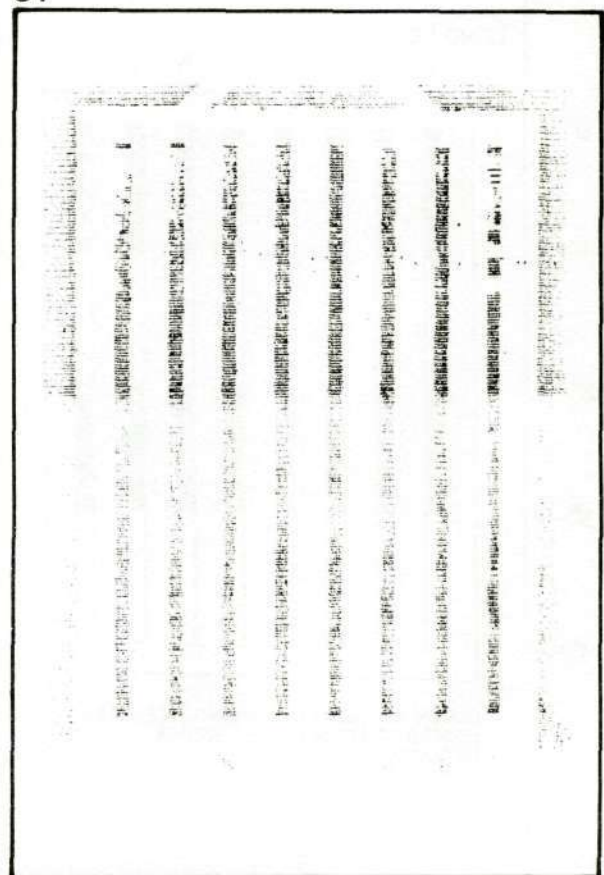
Reproduced from  
best available copy.



HNDT

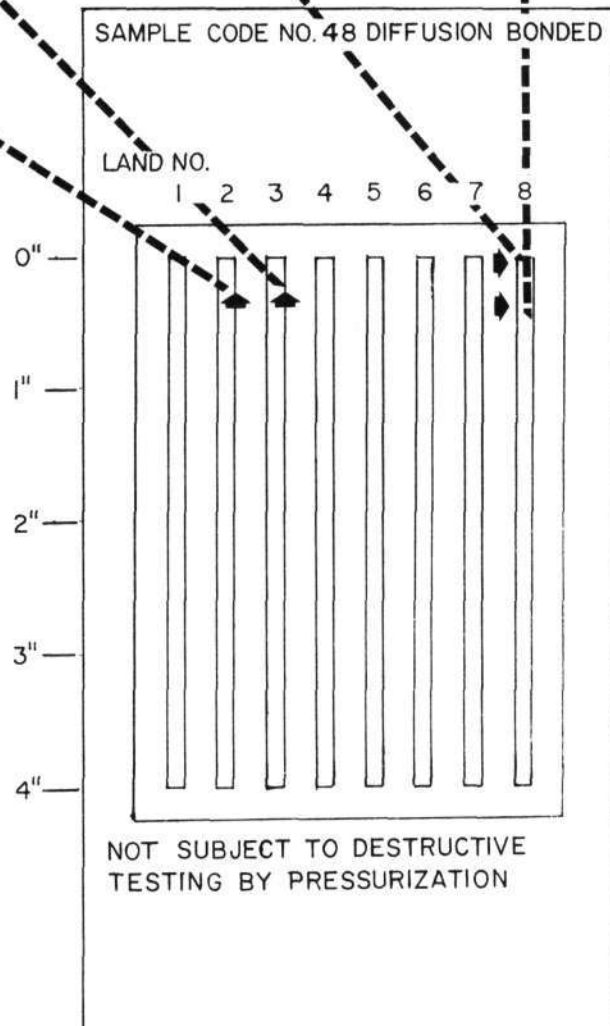
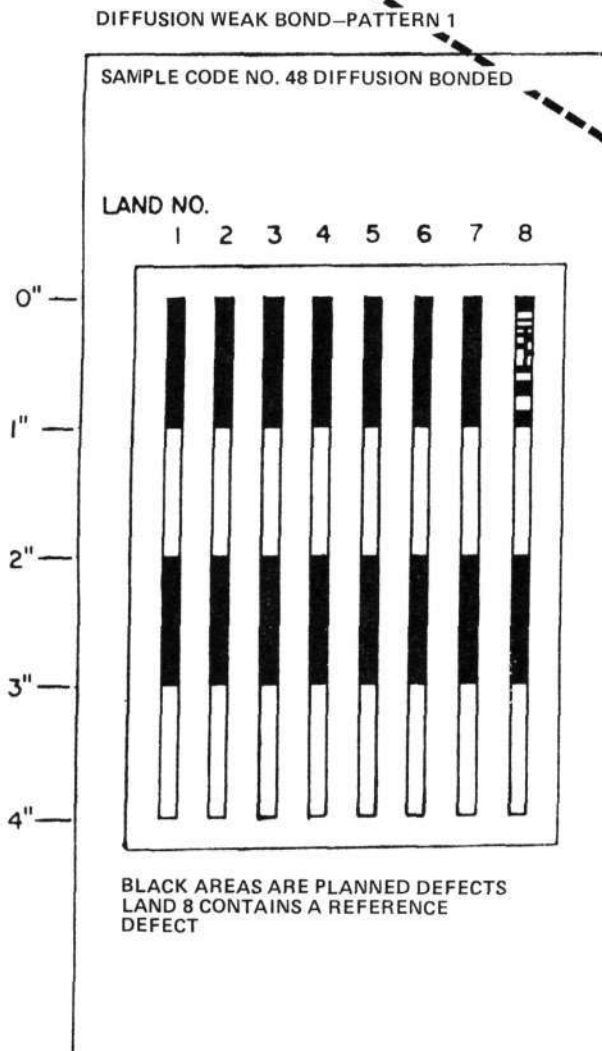
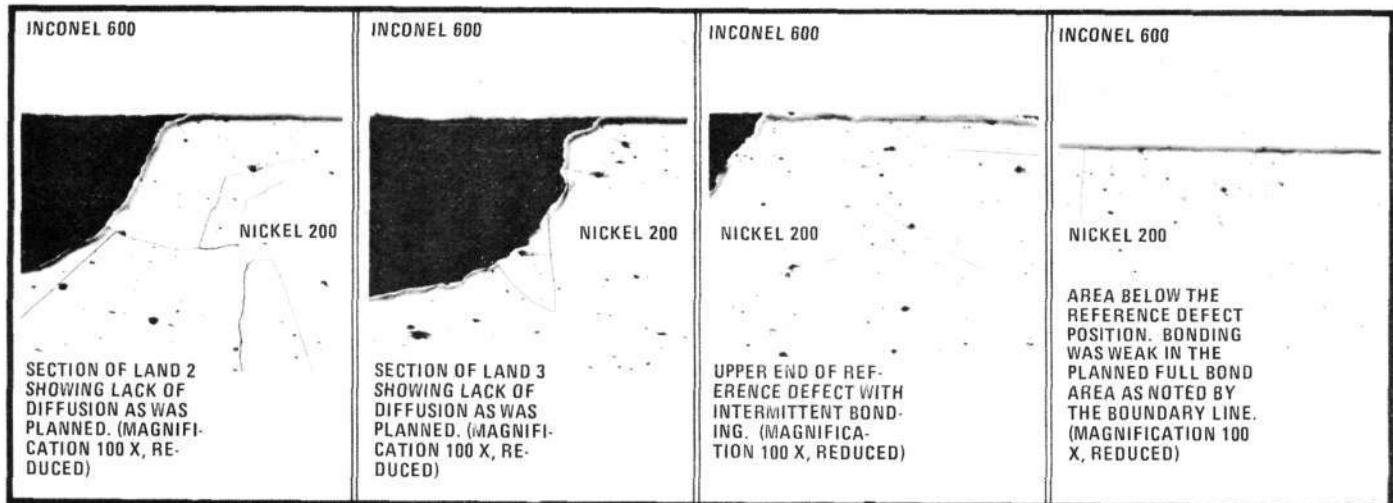


UT



TEST PRESSURE - 500 PSI

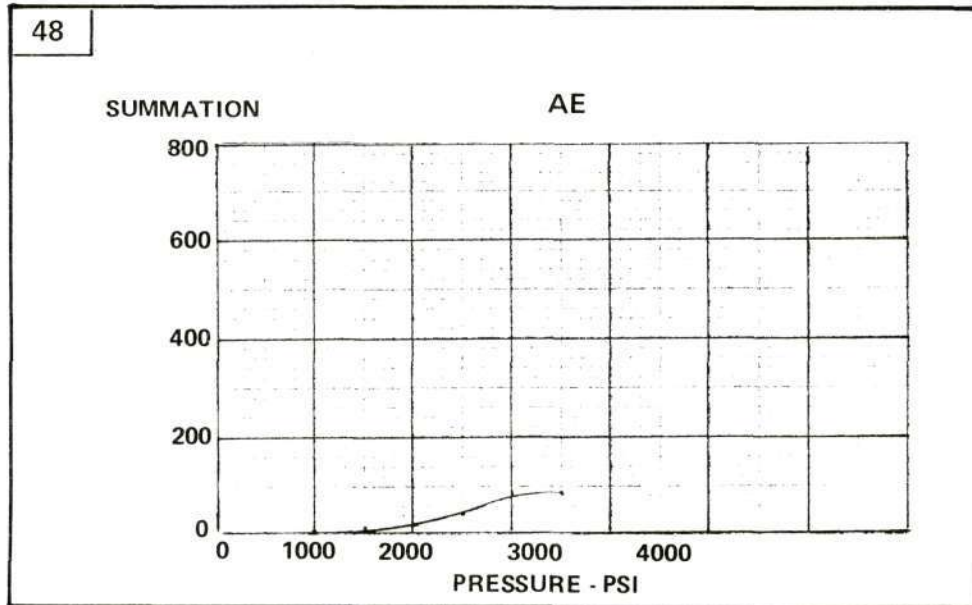




TEST RESULTS ON DIFFUSION WEAK BOND PANEL NO. 48

FIGURE A-37

DIFFUSION CONT'D

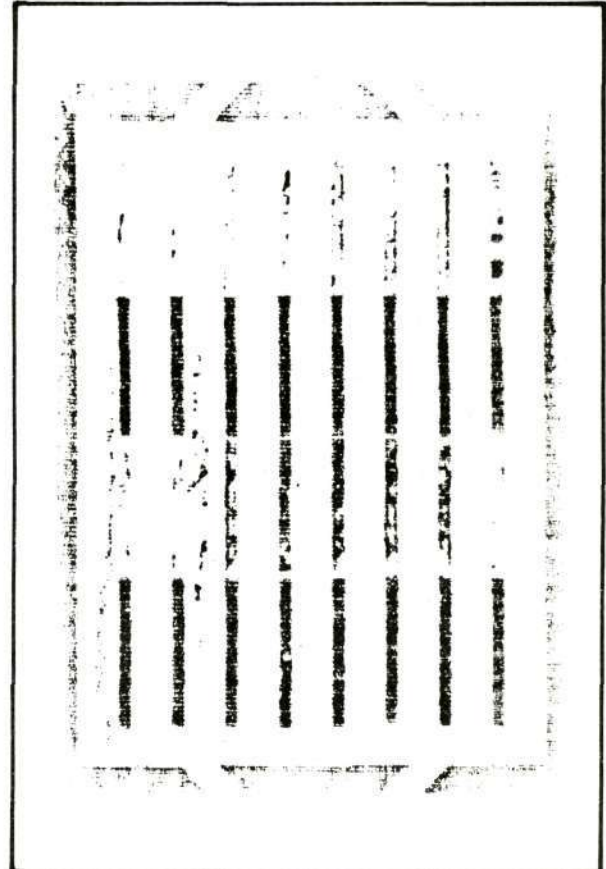


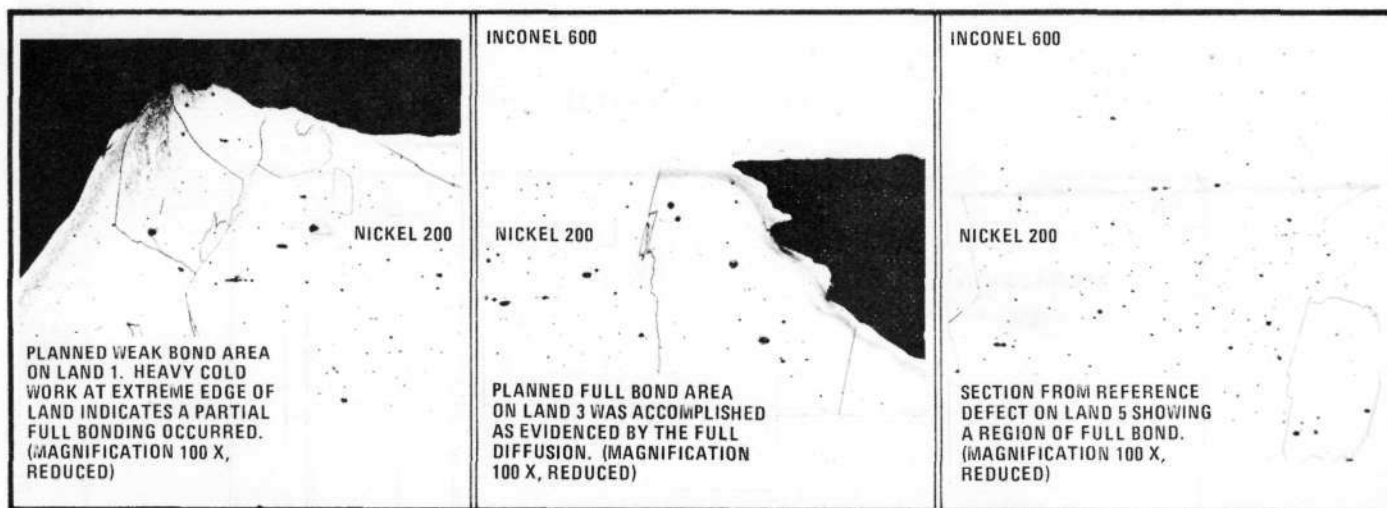
HNDT



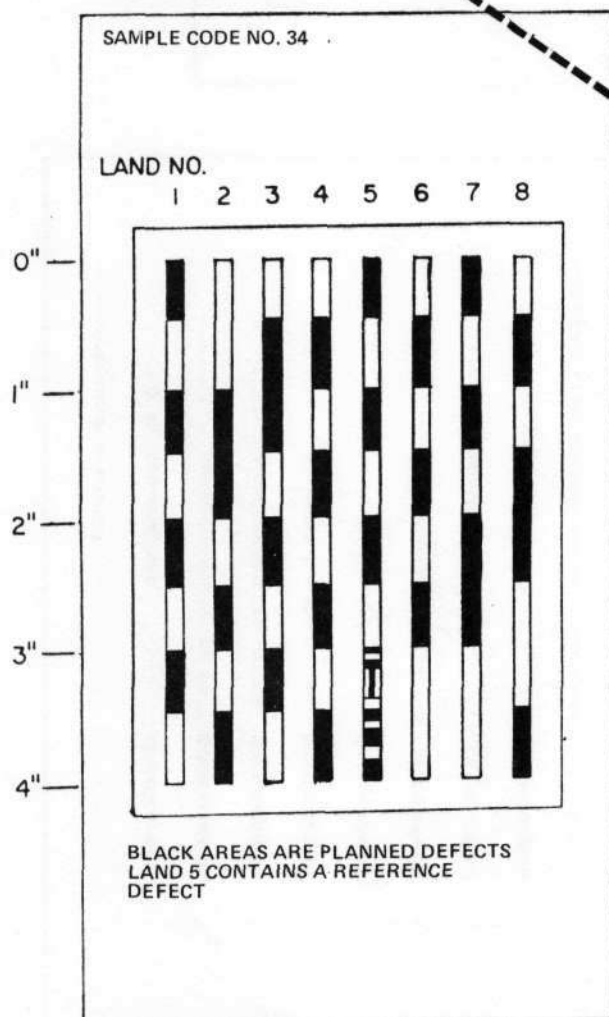
TEST PRESSURE 1400 PSI

UT

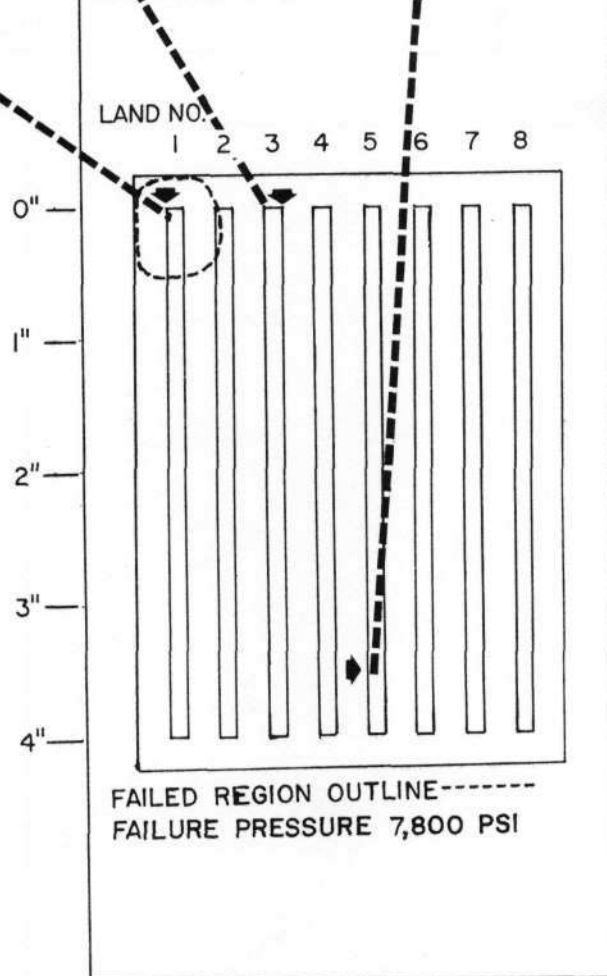




# DIFFUSION WEAK BOND—PATTERN 2



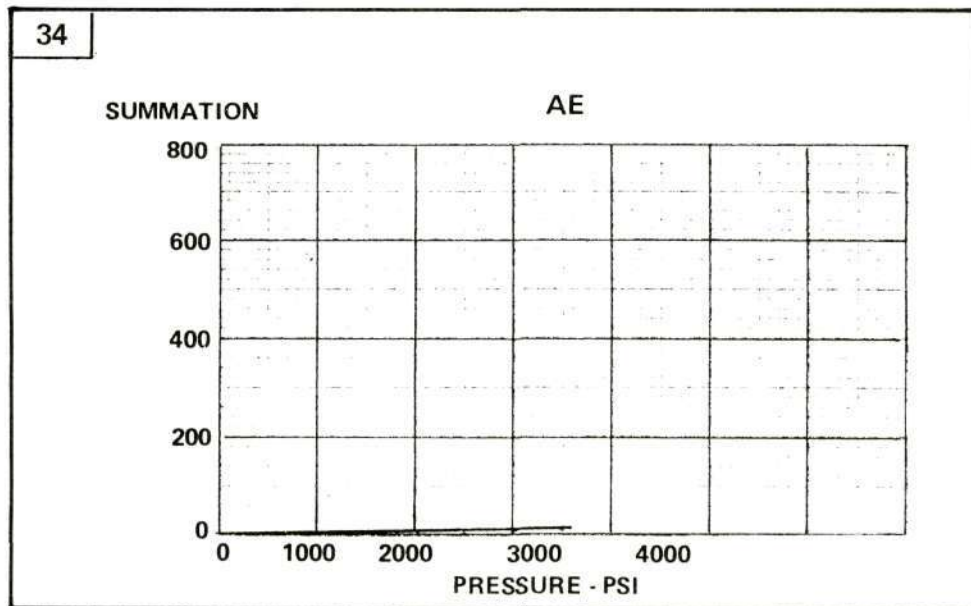
# SAMPLE CODE NO. 34 DIFFUSION BONDED



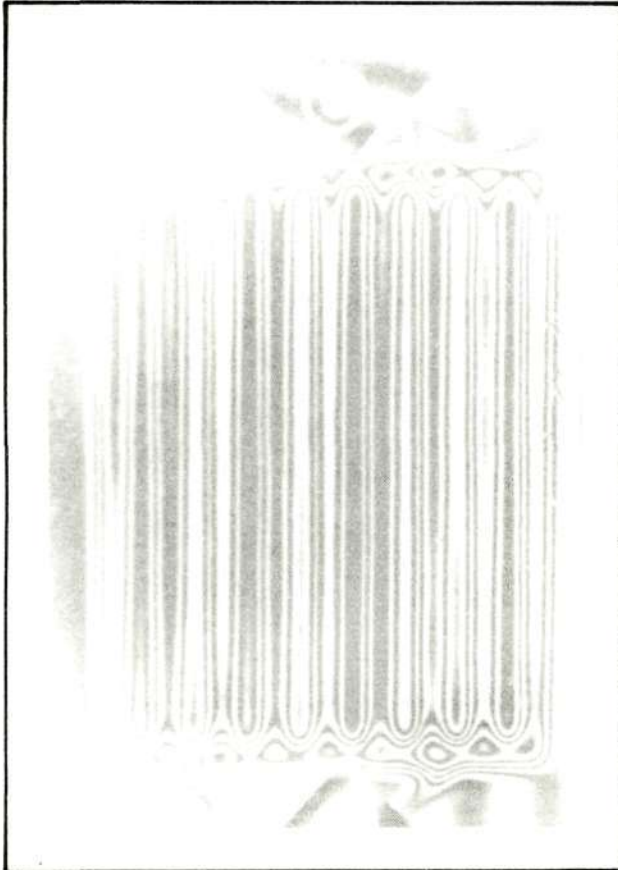
TEST RESULTS ON DIFFUSION WEAK BOND PANEL NO. 34

FIGURE A-38

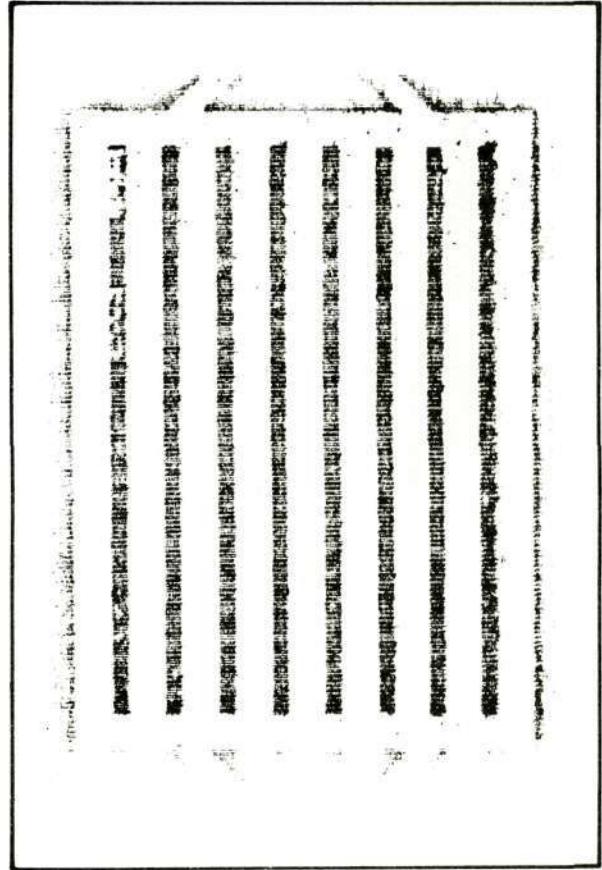
# DIFFUSION CONT'D



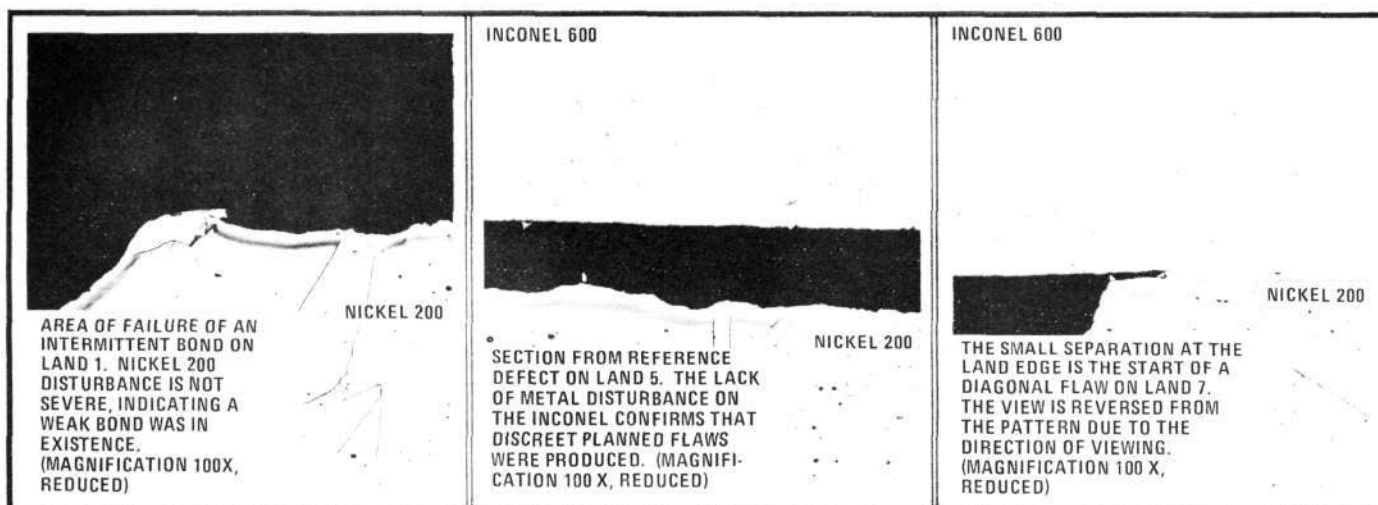
HNDT



UT



TEST PRESSURE 1380 PSI



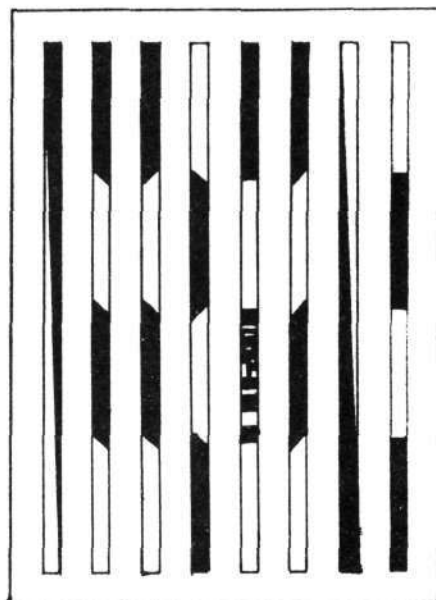
# DIFFUSION WEAK BOND - PATTERN 3

SAMPLE CODE NO. 29

LAND NO.

1 2 3 4 5 6 7 8

0"  
1"  
2"  
3"  
4"



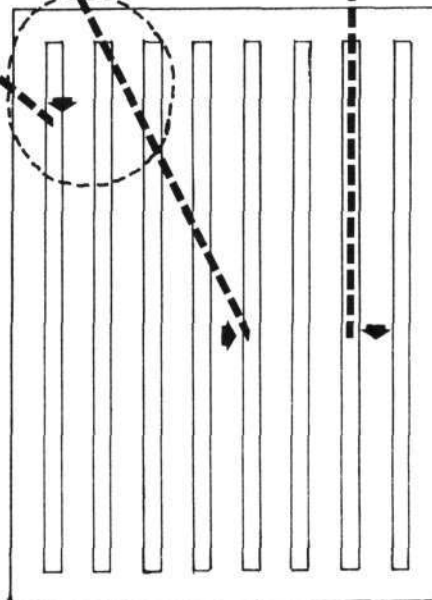
BLACK AREAS ARE PLANNED DEFECTS  
LAND 5 CONTAINS A REFERENCE  
DEFECT

SAMPLE CODE NO. 29 DIFFUSION BONDED

LAND NO.

1 2 3 4 5 6 7 8

0"  
1"  
2"  
3"  
4"



FAILED REGION OUTLINE-----  
FAILURE PRESSURE 8,800 PSI

TEST RESULTS ON DIFFUSION WEAK BOND PANEL NO. 29

FIGURE A-39

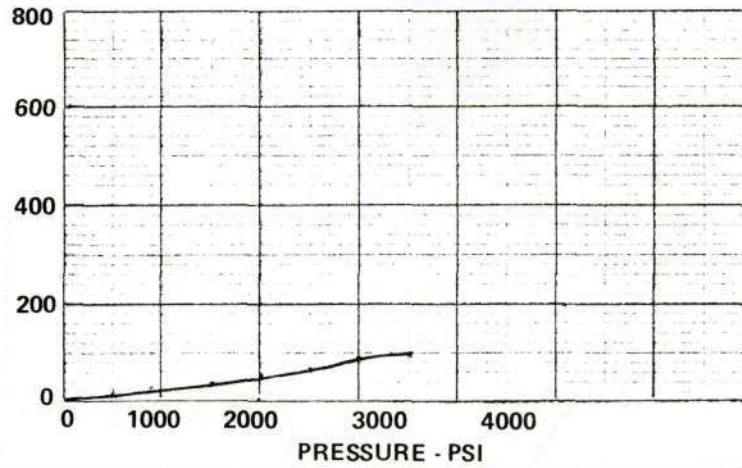


# DIFFUSION CONT'D

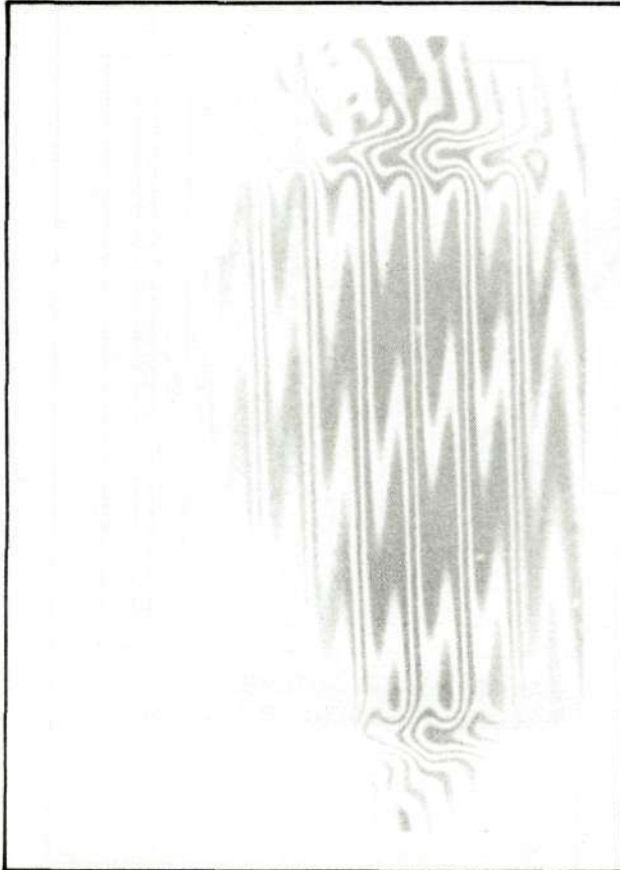
29

SUMMATION

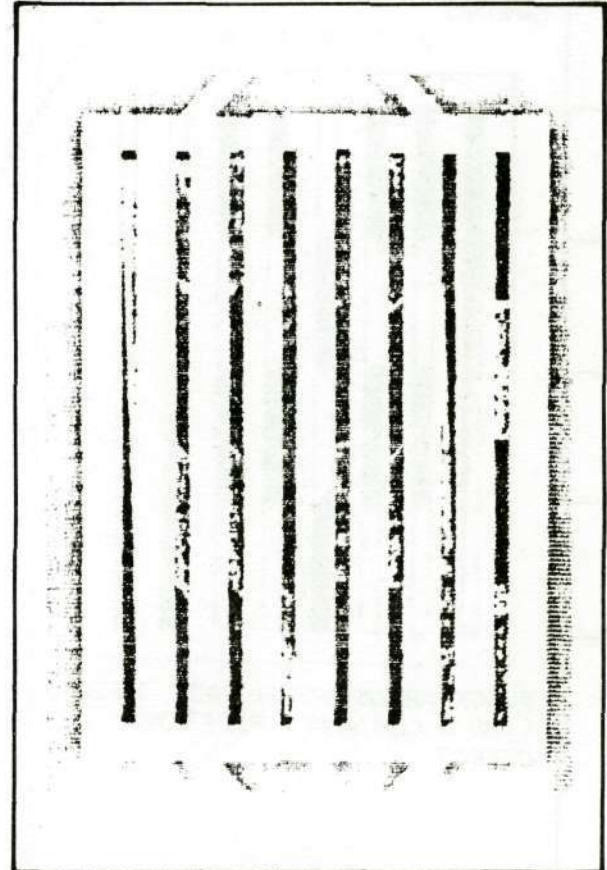
AE



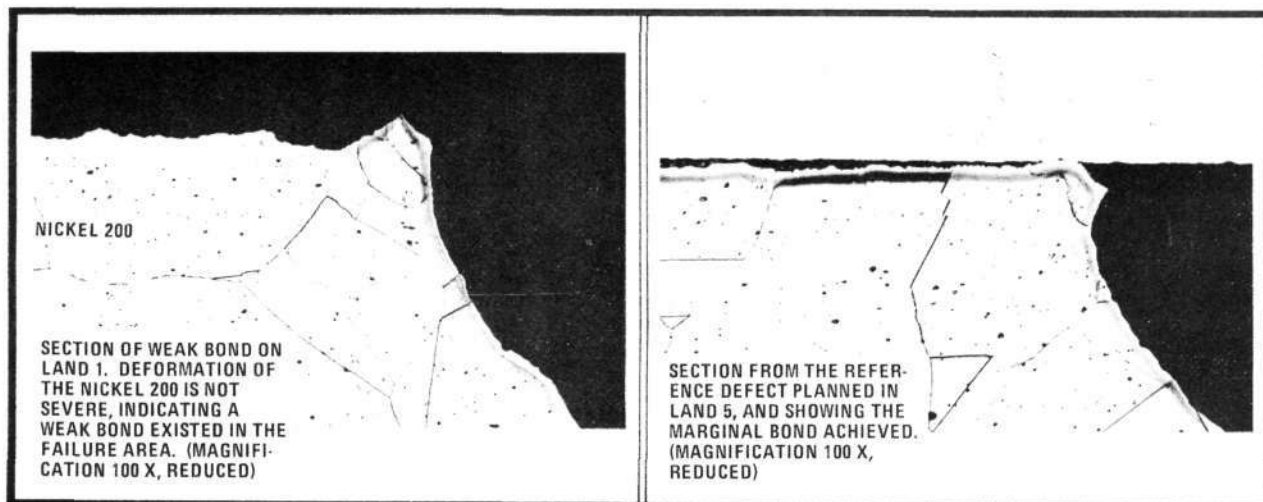
HNDT



UT



TEST PRESSURE 1440 PSI



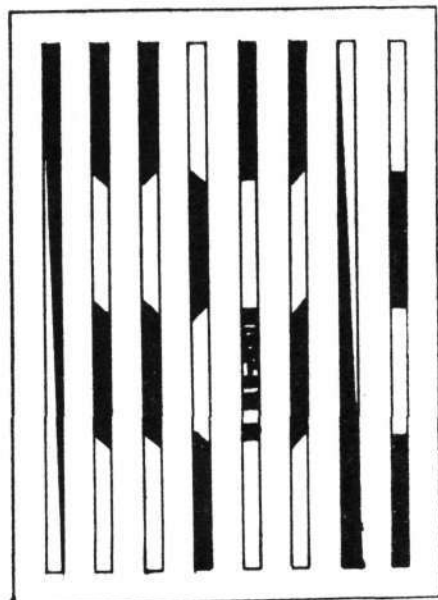
# DIFFUSION WEAK BOND - PATTERN 3

SAMPLE CODE NO. 43

LAND NO.

1 2 3 4 5 6 7 8

0"  
1"  
2"  
3"  
4"



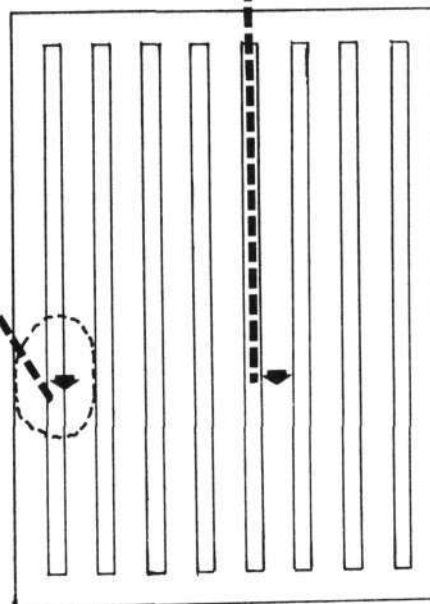
BLACK AREAS ARE PLANNED DEFECTS  
LAND 5 CONTAINS A REFERENCE  
DEFECT

SAMPLE CODE NO. 43 DIFFUSION BONDED

LAND NO.

1 2 3 4 5 6 7 8

0"  
1"  
2"  
3"  
4"



FAILED REGION OUTLINE-----  
FAILURE PRESSURE 8,000 PSI

TEST RESULTS ON DIFFUSION WEAK BOND PANEL NO. 43

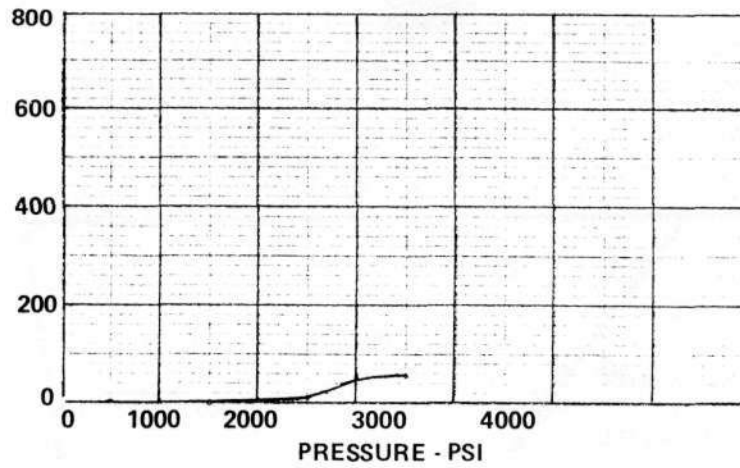
FIGURE A-40

# DIFFUSION CONT'D

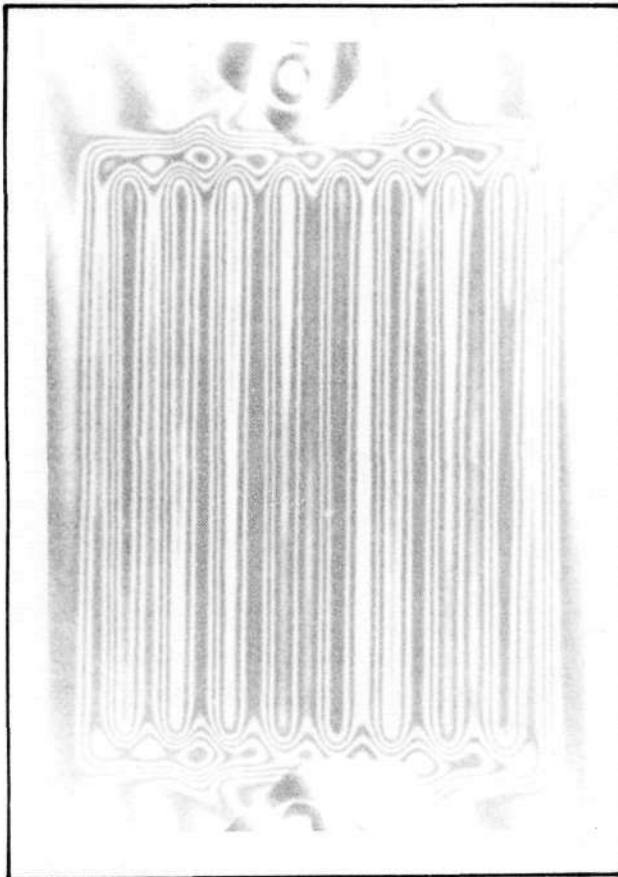
43

SUMMATION

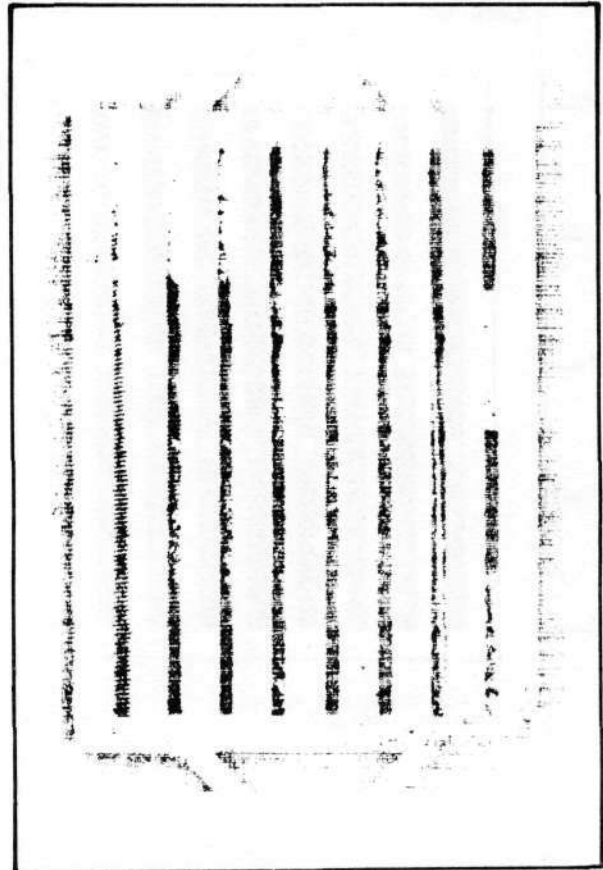
AE



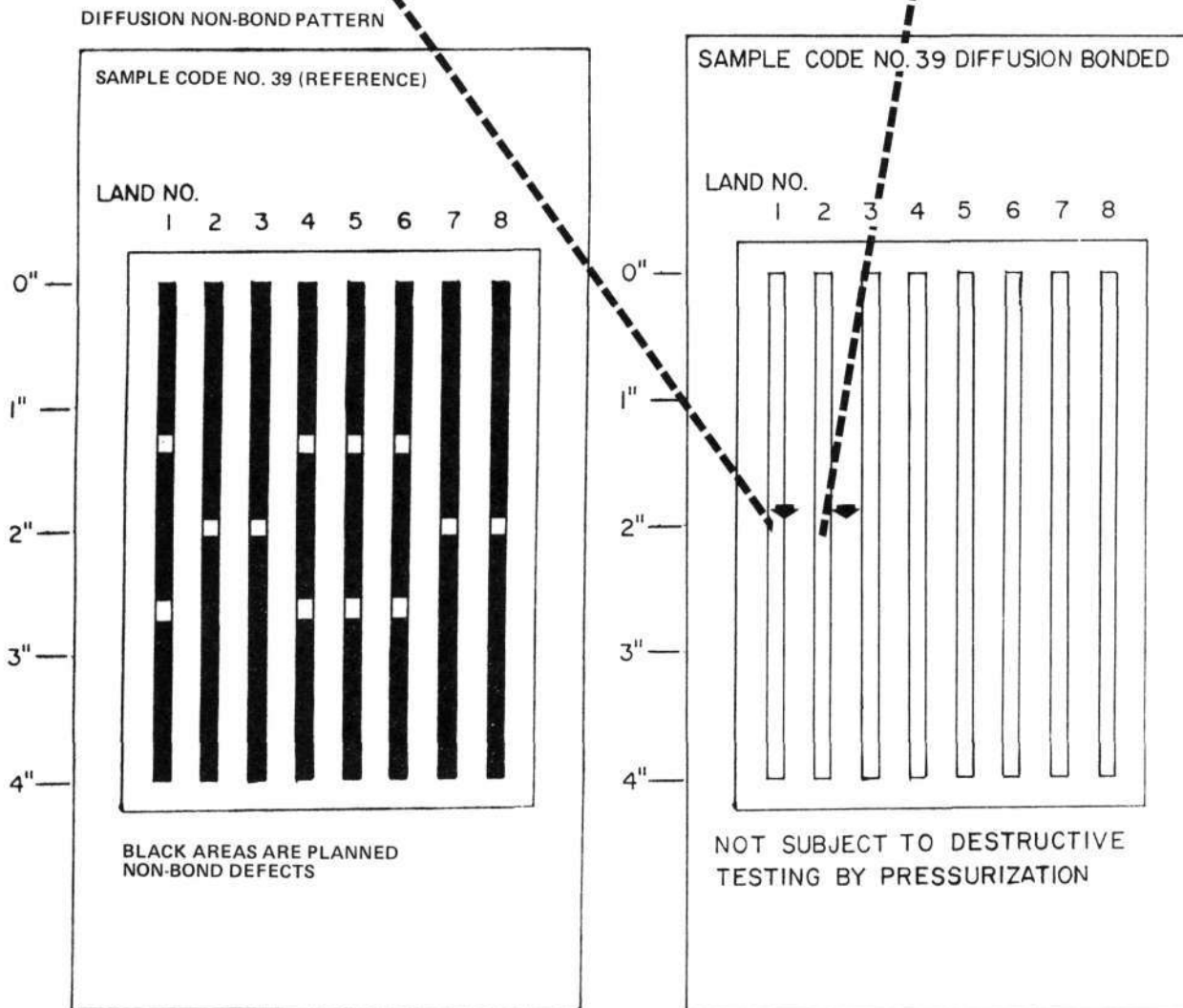
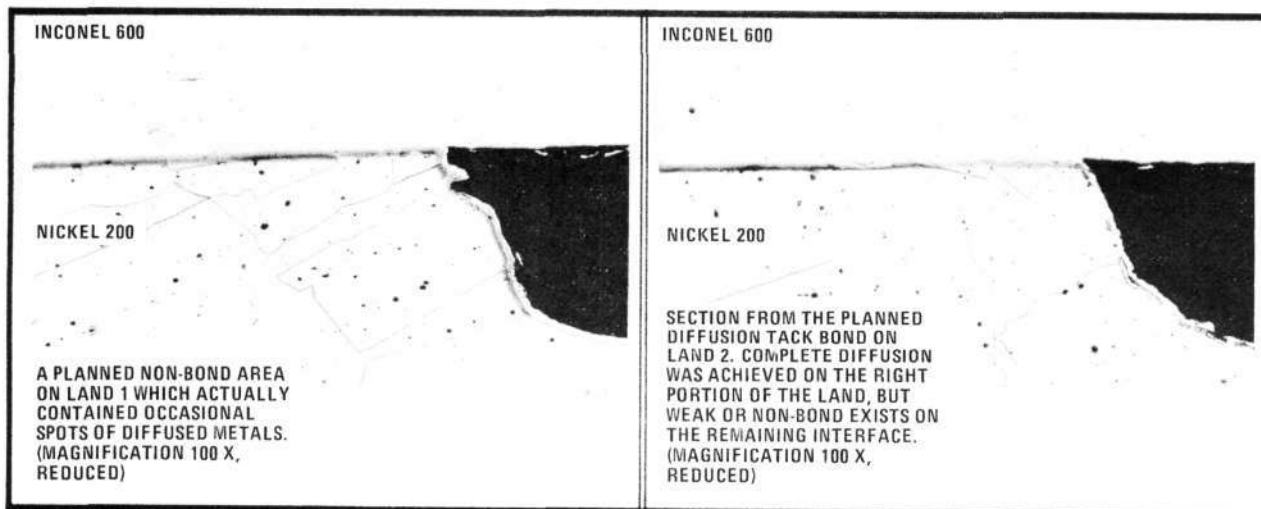
HNDT



UT



TEST PRESSURE 1400 PSI



TEST RESULTS ON DIFFUSION NON-BOND PANEL NO. 39

FIGURE A-41



# DIFFUSION CONT'D

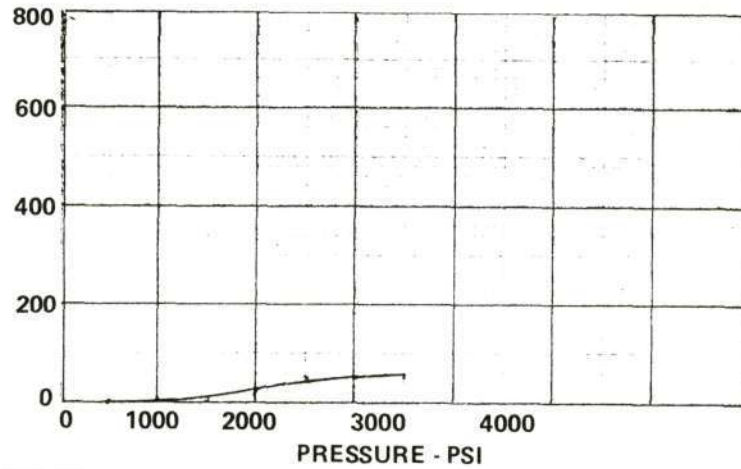
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best available copy.



39

SUMMATION

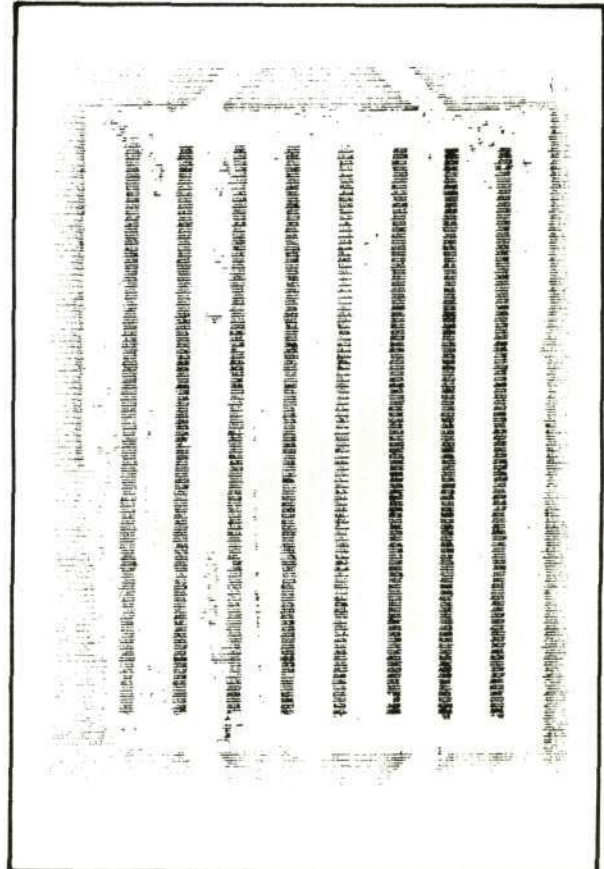
AE



HNDT

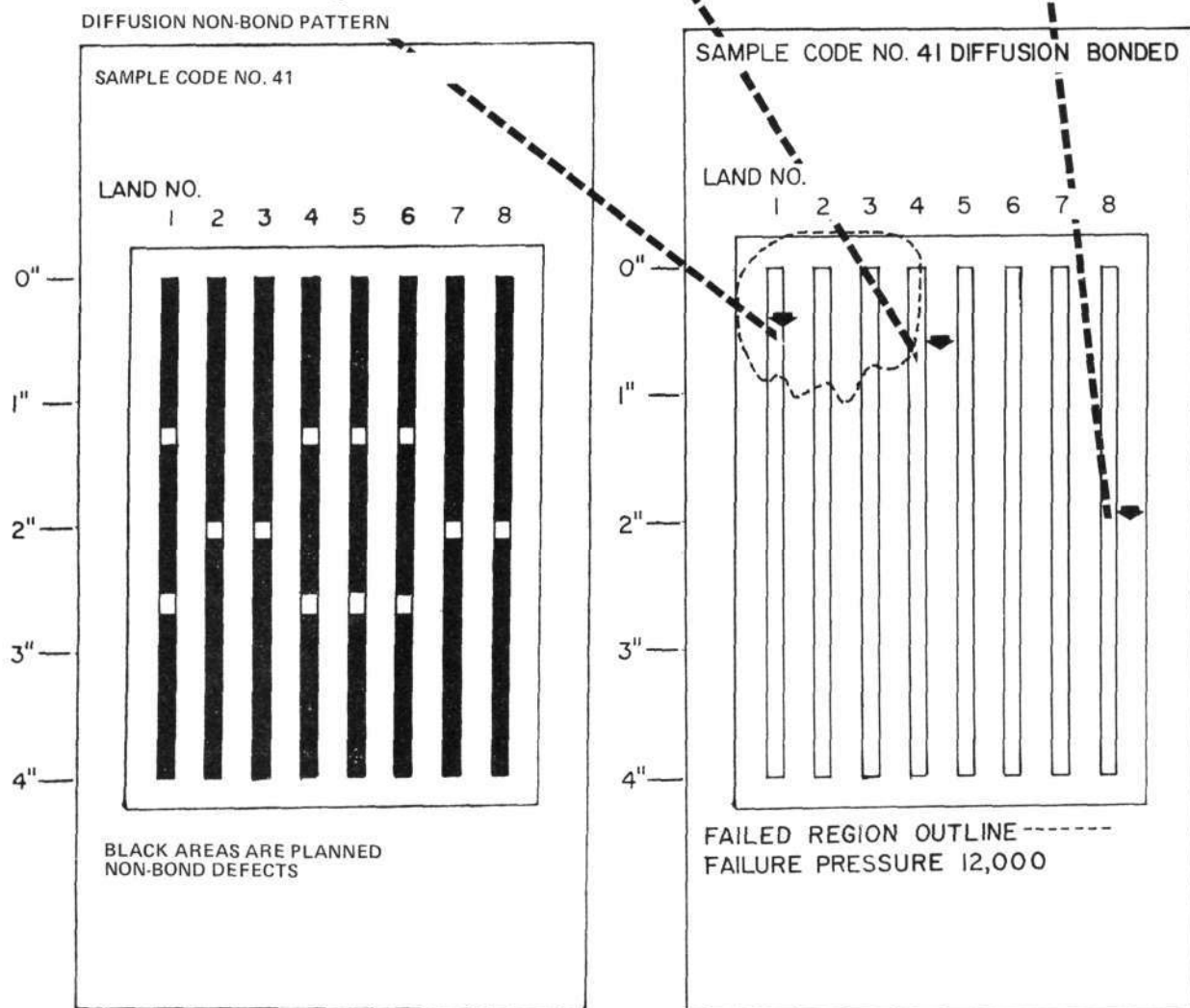
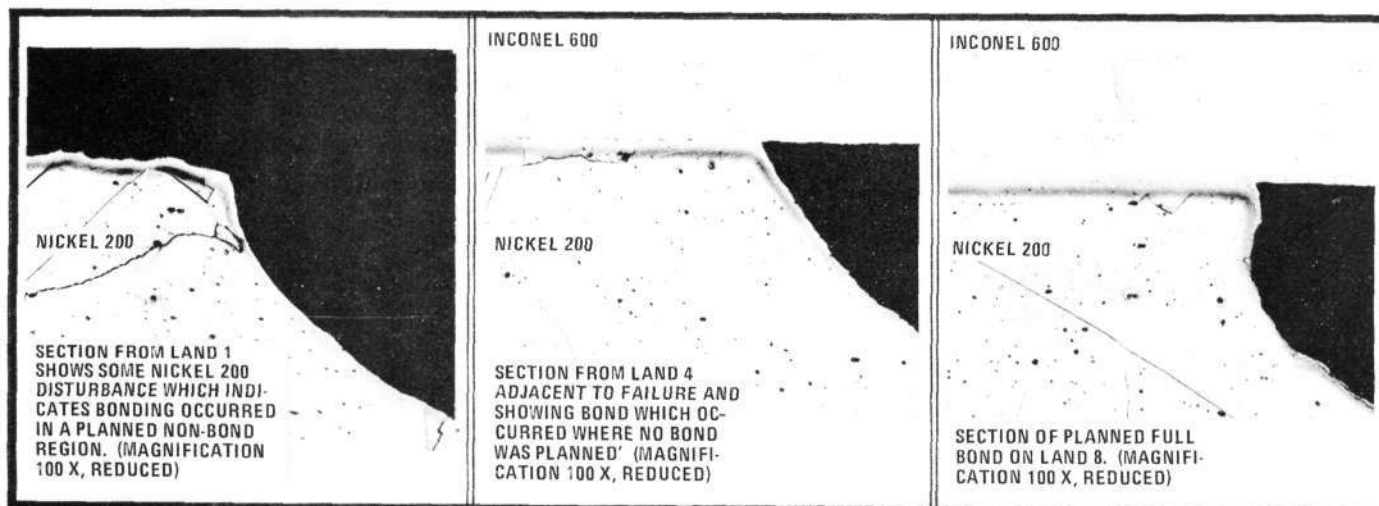


UT



TEST PRESSURE 1380 PSI

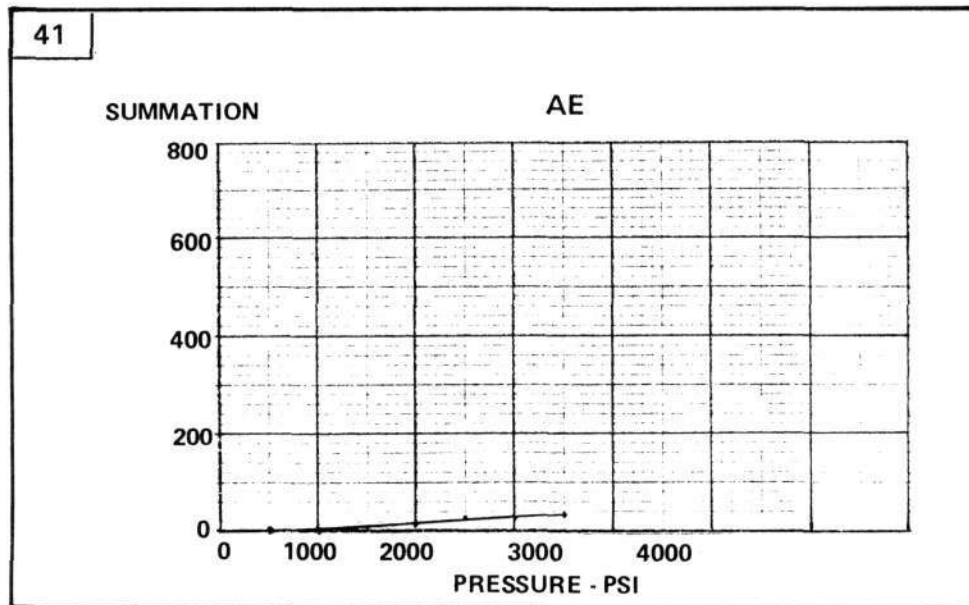




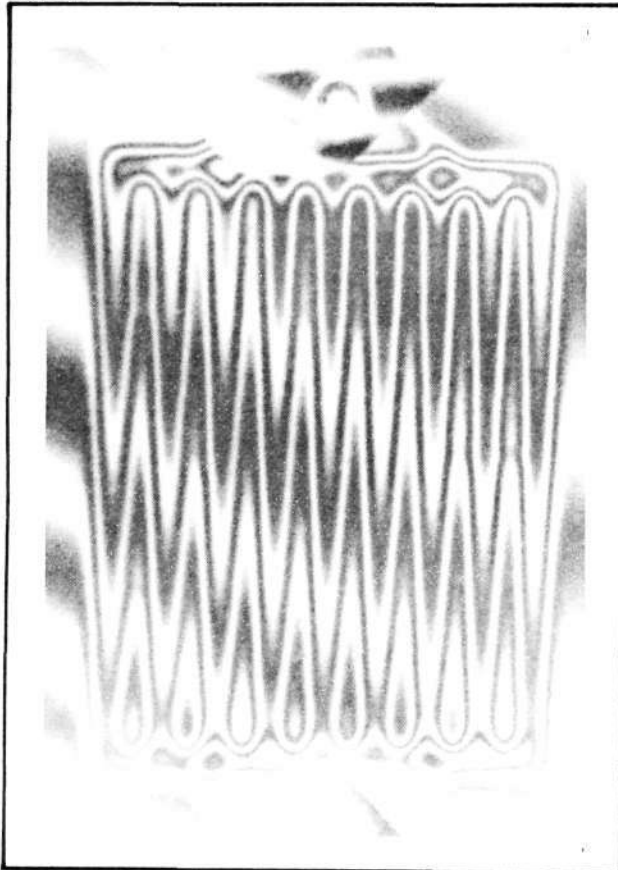
TEST RESULTS ON DIFFUSION NON-BOND PANEL NO. 41

FIGURE A-42

# DIFFUSION CONT'D

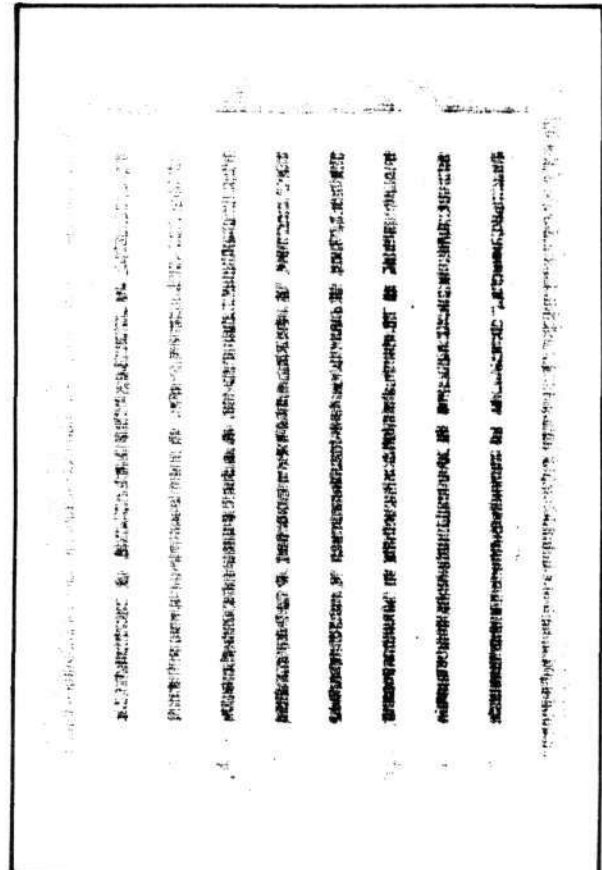


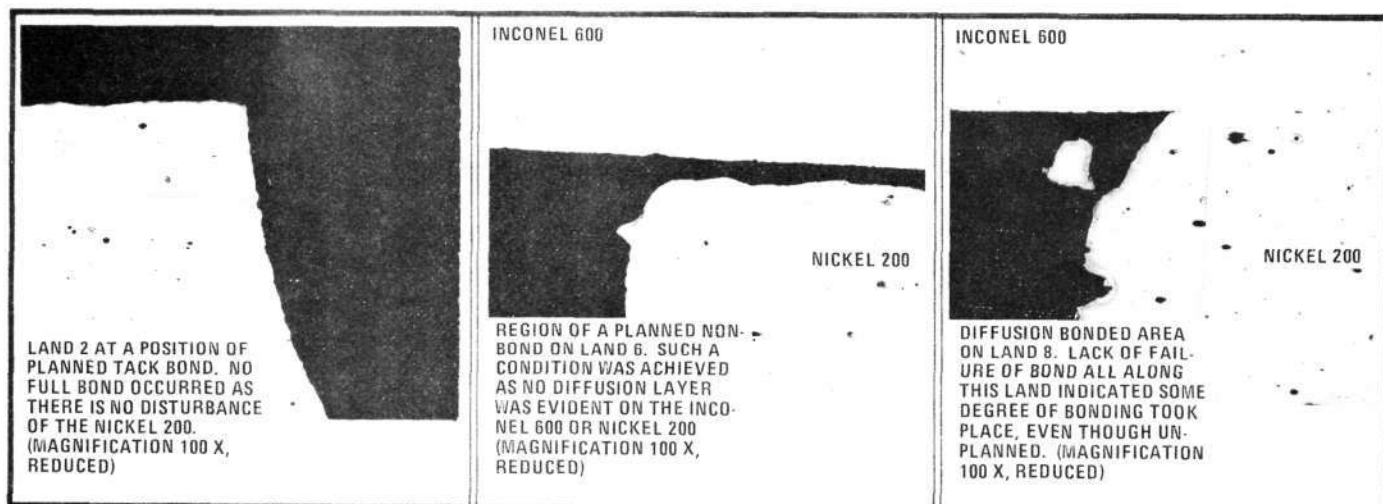
HNDT



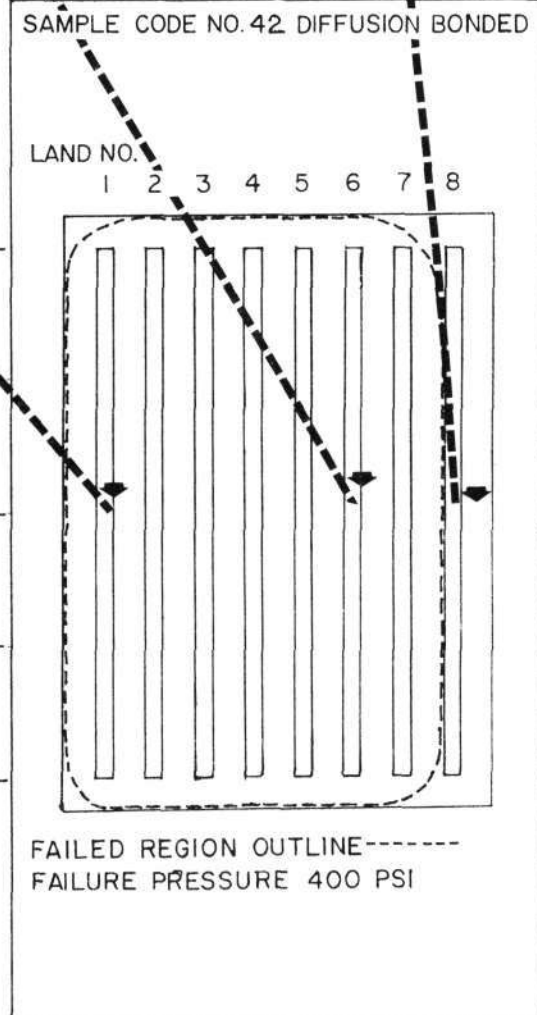
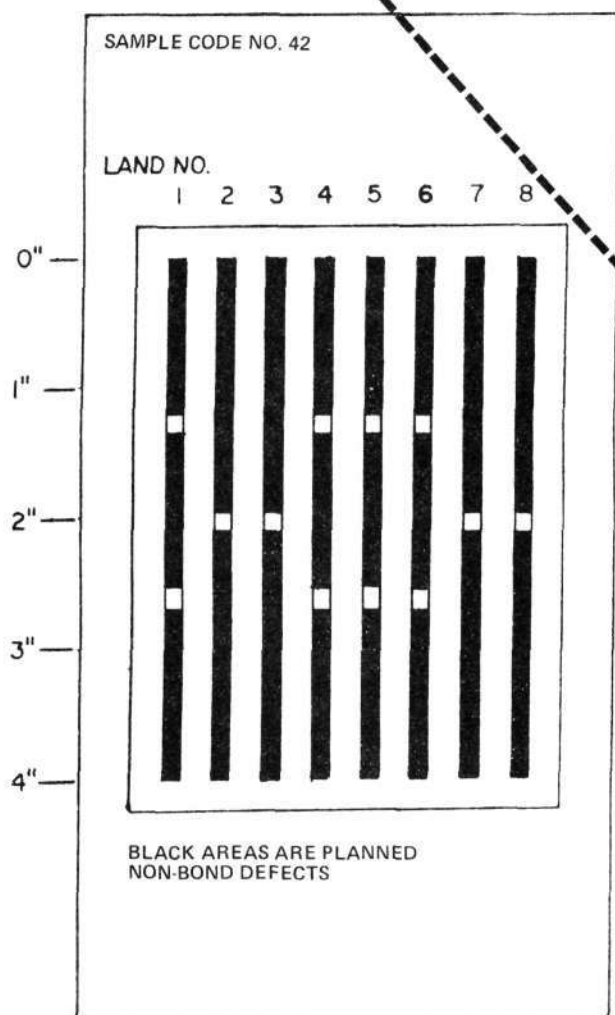
TEST PRESSURE 1400 PSI

UT





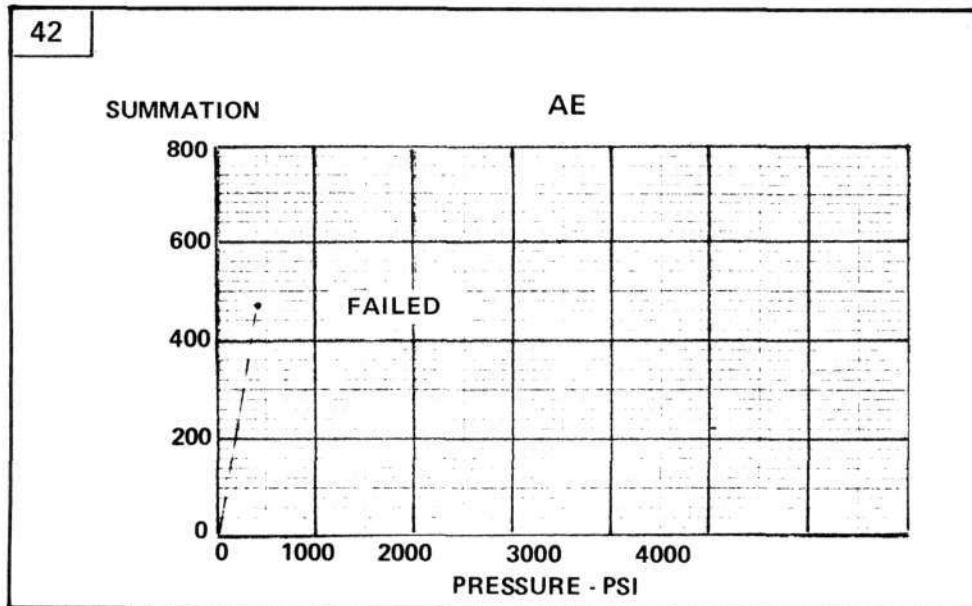
# DIFFUSION NON-BOND PATTERN



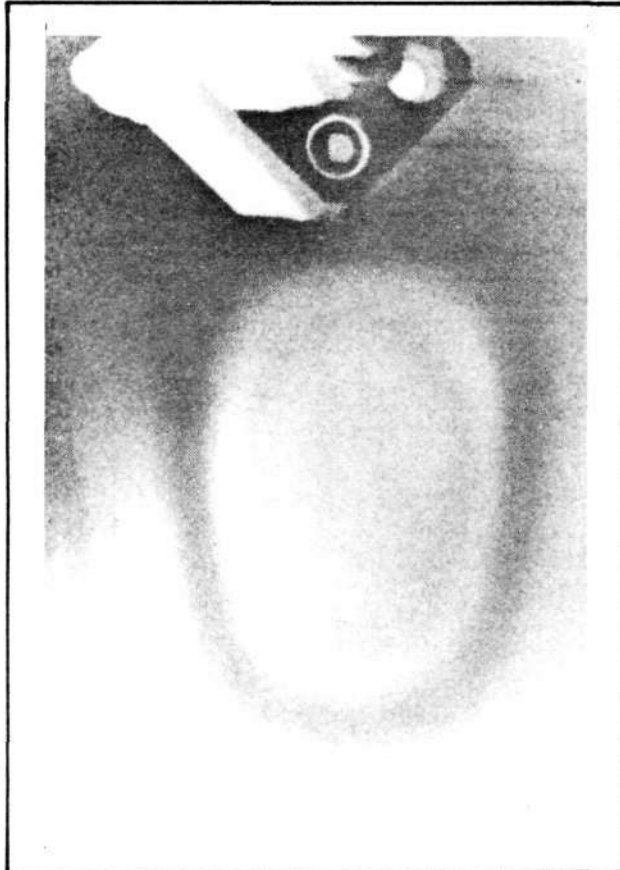
TEST RESULTS ON DIFFUSION NON-BOND PANEL NO. 42

FIGURE A-43

# DIFFUSION CONT'D

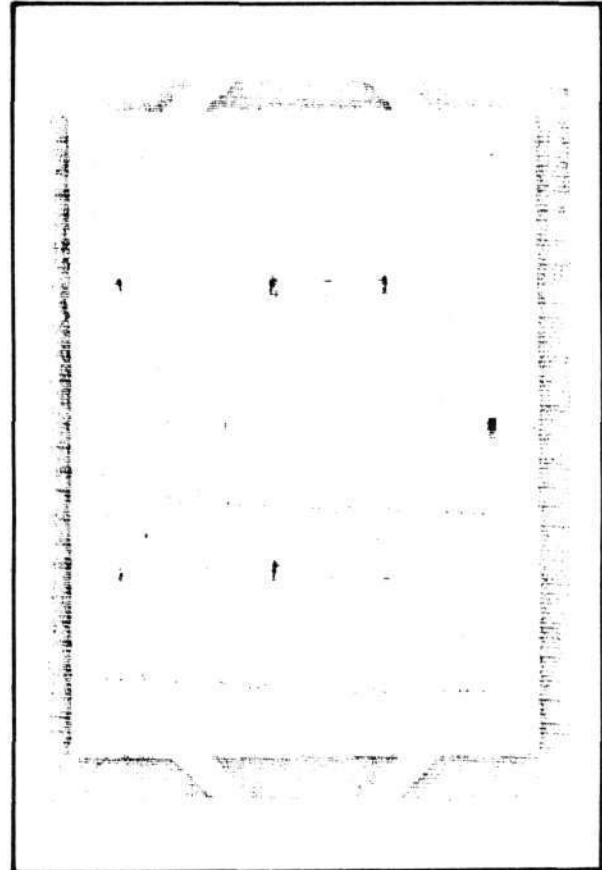


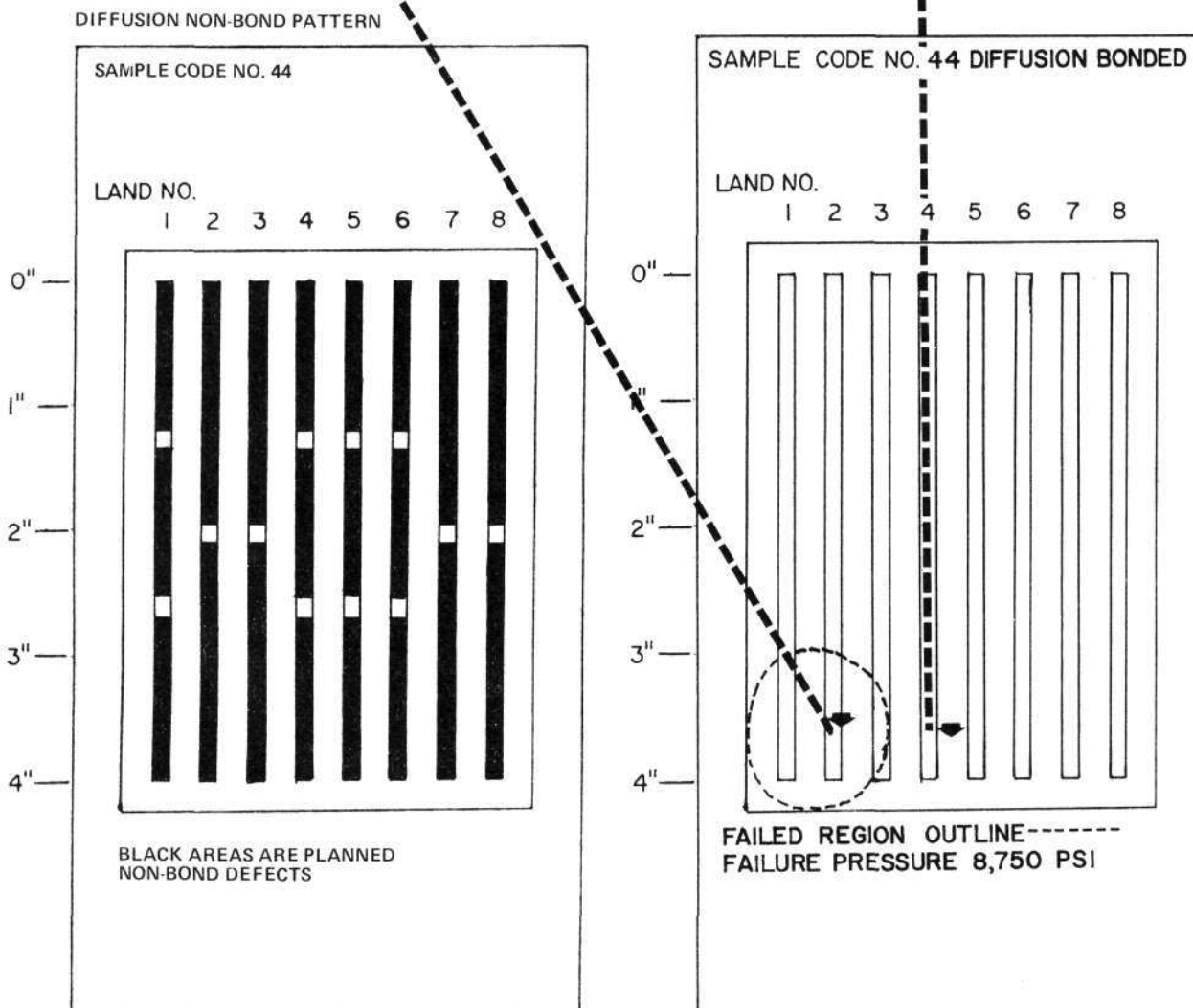
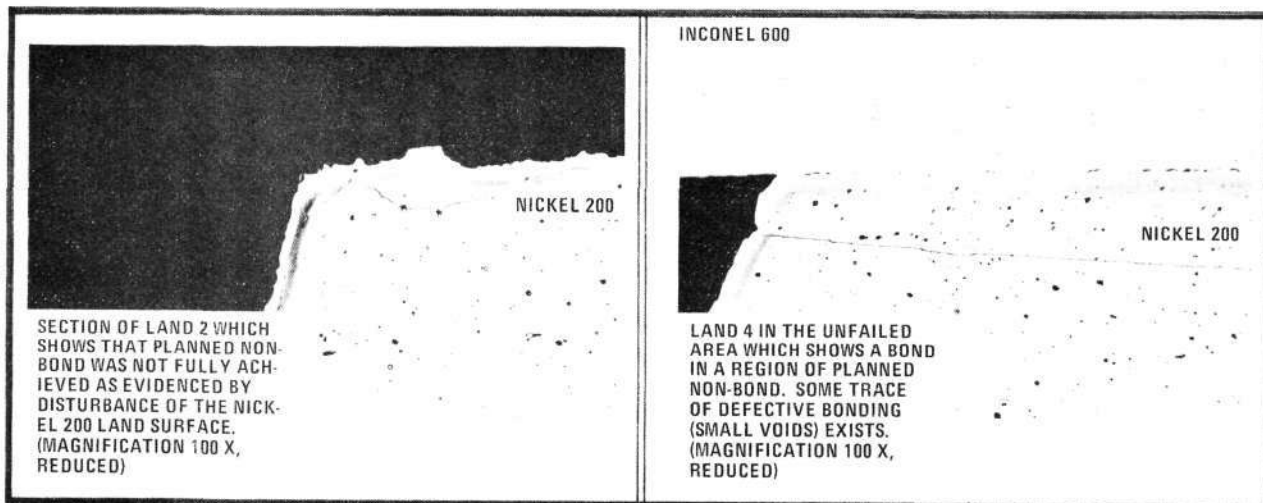
HNDT



TEST PRESSURE 50 PSI

UT



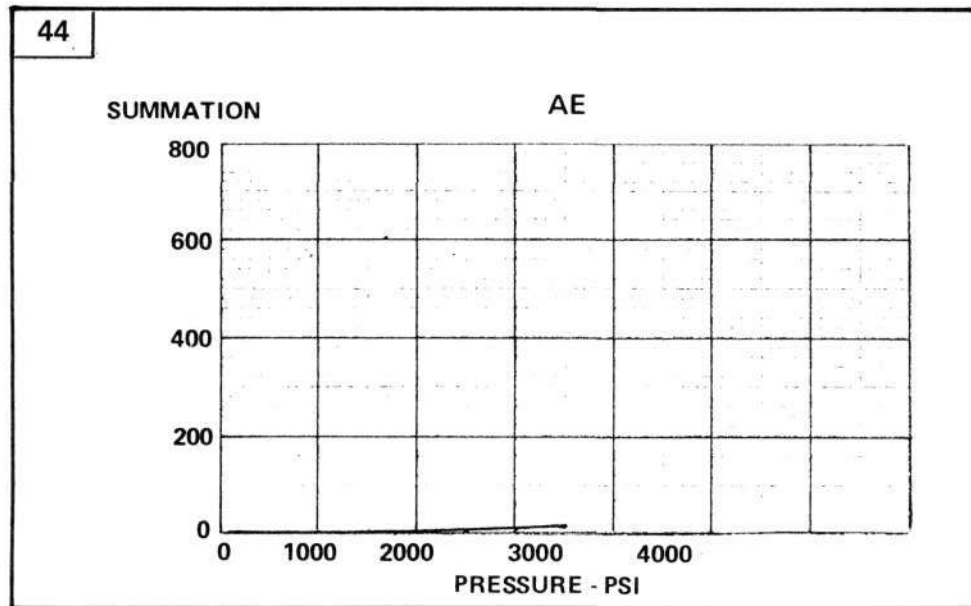


TEST RESULTS ON DIFFUSION NON-BOND PANEL NO. 44

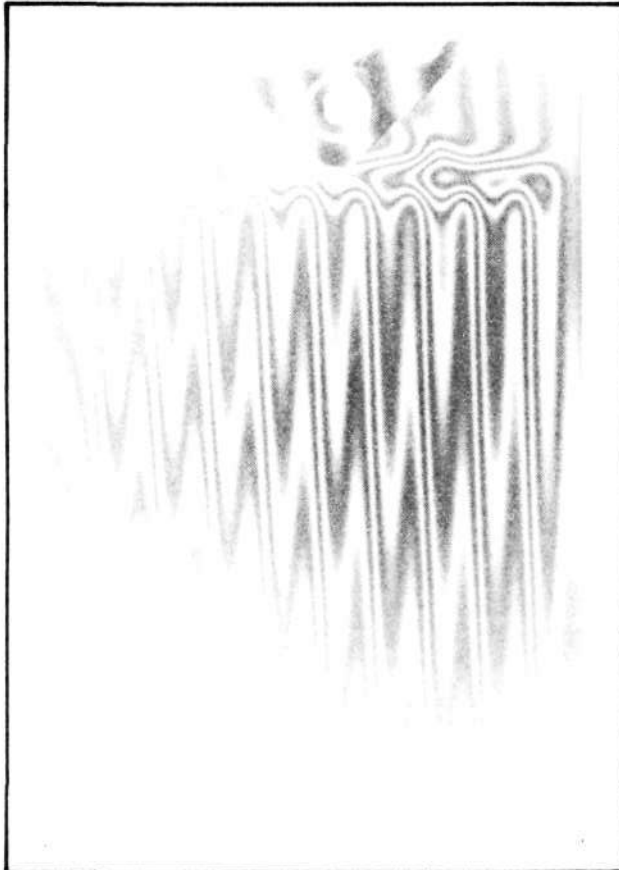
FIGURE A-44



# DIFFUSION CONT'D

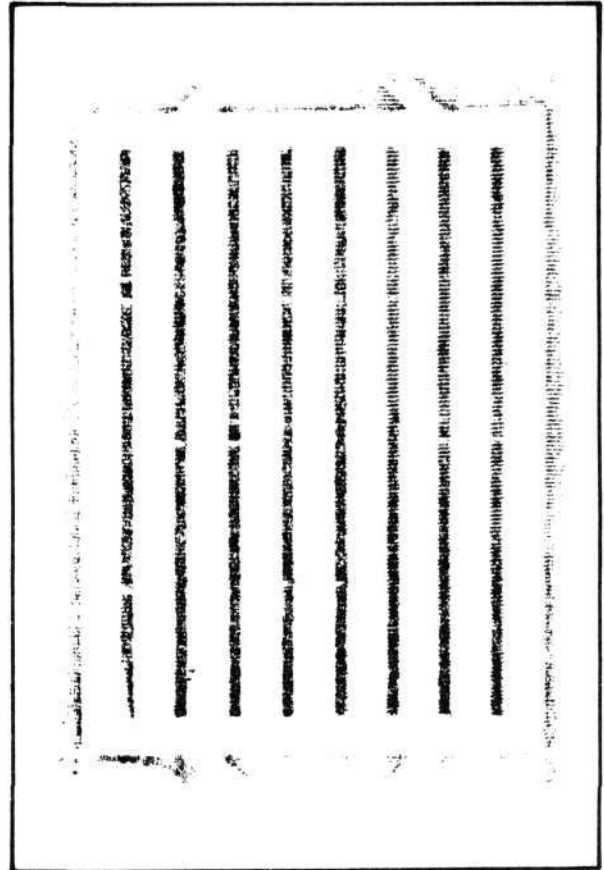


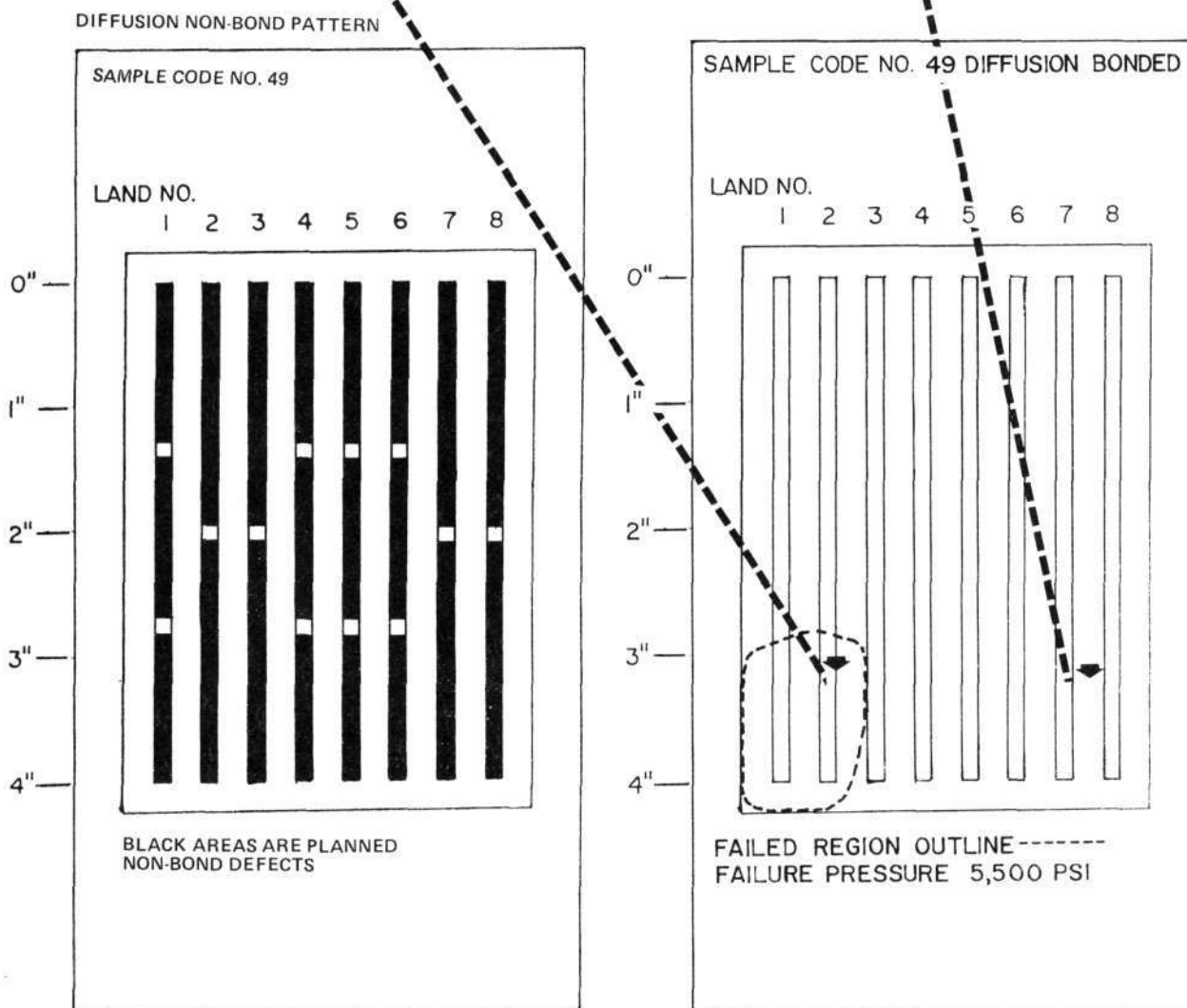
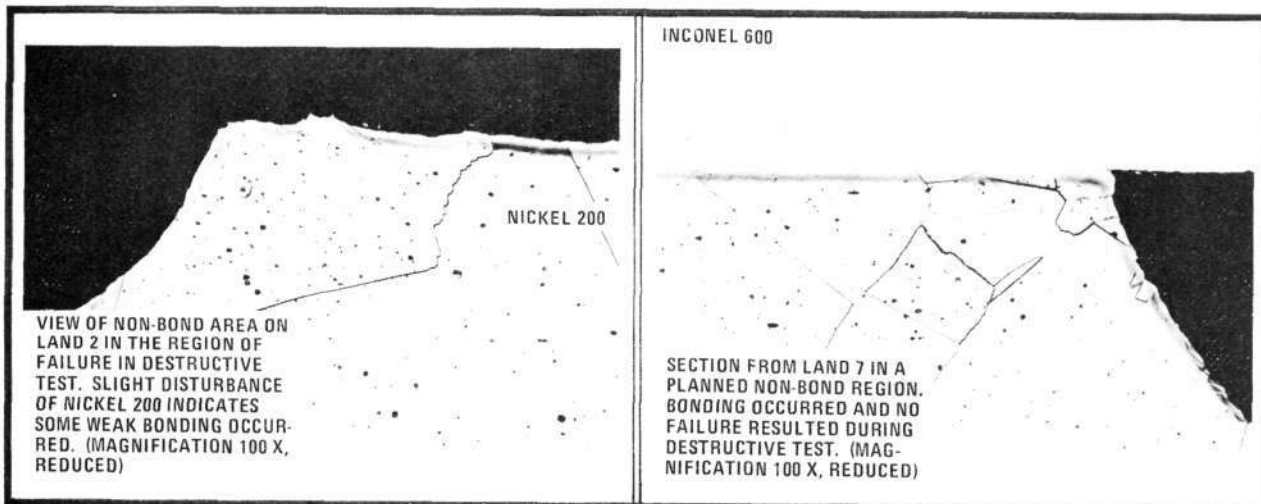
HNDT



TEST PRESSURE 1400 PSI

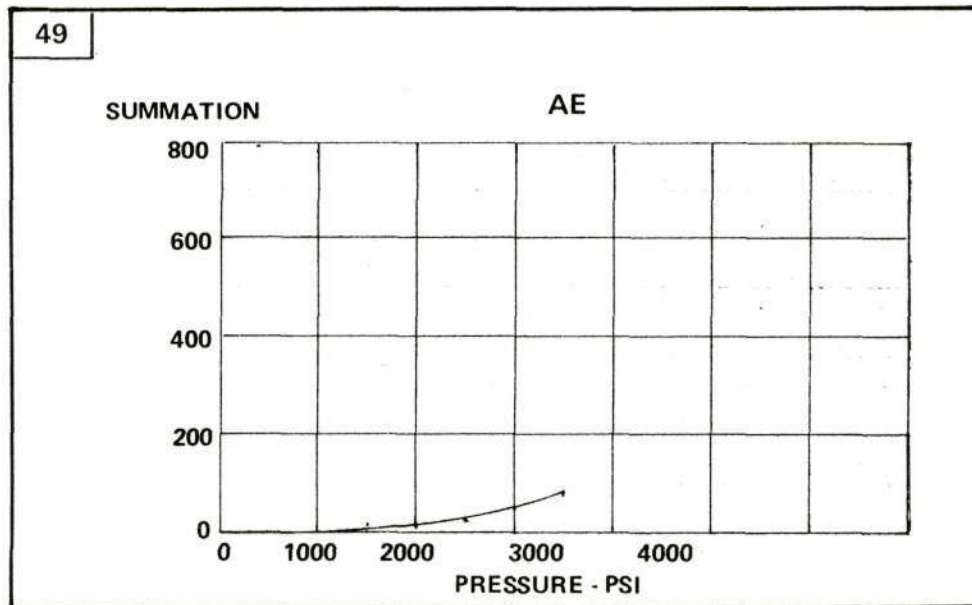
UT



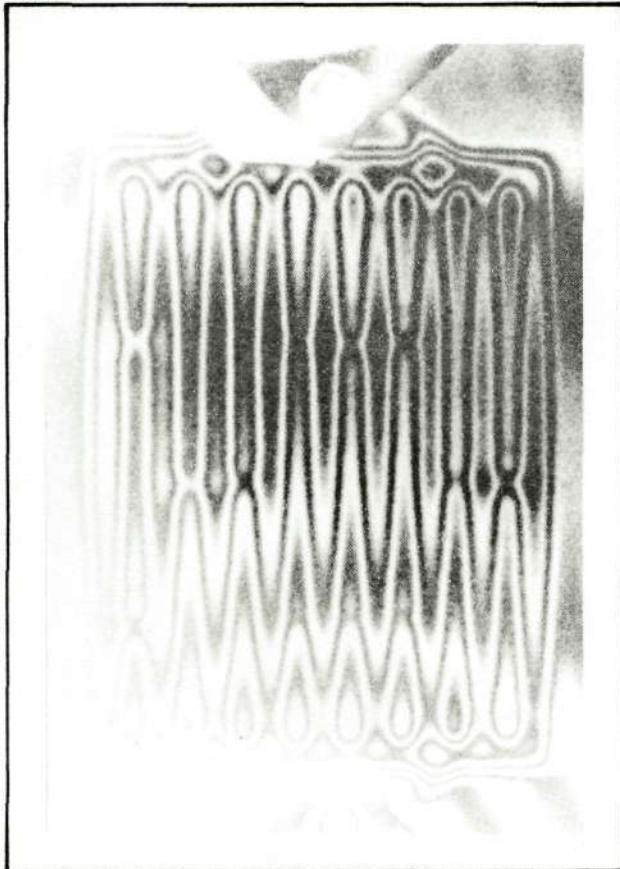


TEST RESULTS ON DIFFUSION NON-BOND PANEL NO. 49

FIGURE A-45



HNDT



TEST PRESSURE 1400 PSI

UT

